New Fields for Brewers

And others active in the Fermentation and Allied Industries

Edited by

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A Complete and Comprehensive Reference Book

FOR

Beverage Manufacturers, Bottlers, Brewers, Brewing Chemists, Distillers, Food Chemists, Maltsters, Students

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To

WM. F. CARTHAUS

President of the Master Brewers' Association of the United States

This Book is Dedicated
In Token of Warm Personal Regard

THE AUTHOR

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Preface

THE fermentation and allied industries have reached a stage where an expansion into other lines appears expedient if the enormous capital investments are to be conserved throughout the period of reconstruction upon which these industries already have entered.

The anti-liberal forces are so well organized that they are no longer negligible factors, and the prohibition of all alcoholic beverages in certain of our states is now a subject of deep concern in all sections of this country. While National Prohibition forced upon the people of this country by a minority of the population through constitutional amendment, can at its best be only transitory in its results, it may, nevertheless, lead to a wholesale destruction of property and the throwing out of employment of thousands of trained men, unless ways and means are found to substitute, at least temporarily, other fields of manufacture closely associated with these industries and in which the specialized experience accumulated in years of practice, may be profitably employed.

There are only a few industries and industrial undertakings in which the experience of the brewer and those active in the allied industries can be of value. The peculiar construction of the brewery, and the nature of its equipment, unfortunately make it difficult of adaptation to other manufacturing pursuits, and the NEW FIELDS open for the

brewer are necessarily limited. These industries, however, must bridge the temporary chasm until a new foundation has been laid for a greater brewing industry, coming victoriously as one purified and freed of the evils which have been incident to it, through this period of transformation.

It is with the object of pointing the way that this little volume has been written. At present there is no similar work available which fills this urgent need. It consists of an exposition of those industries with which the brewer, and others active in fermentation lines, can easily familiarize themselves.

In the preparation of this book the Author has departed from the customary methods of treatment employed in the preparation of industrial and scientific reference books, and as a result the arrangement of the subject matter may at its first reading appear somewhat unusual. For this reason a few words of explanation may be in place. It frequently occurs that books on industrial chemistry are burdened with excessive detail, thereby detracting the attention of the readers from the basic principles of the subject under discussion. It has, therefore, been found not only expedient, but necessary, to dispense with all details, in a book of this scope and to present only, as it were, a picture of the various industries sufficiently accurate, however, so that the reader might be able to judge for himself whether it would be worth his time and efforts to go into a more intense study of one or the other of these industries. In order to facilitate

further study a complete bibliography of the more recent literature on the industries under discussion has been made the main feature of this book.

The present work is essentially a book of suggestions. The Editor is of the opinion that more practical and useful information can be gathered from the suggestions contained in patent specifications than in any other way. Frequently, patent specifications are the only source of information appearing in regard to certain technical processes. Those familiar with patent literature know that the majority of patents taken out by inventors are not practical, and many of them have never been put into practice. Nevertheless, they contain useful ideas which, in conjunction with practical experience and some research, may be developed into highly remunerative industrial undertakings. It is for this reason that a large number of suggestions have been made and should serve as a valuable nucleus for further development.

Particular pains have been taken to incorporate only such industries as are actually sound and remunerative. In dealing with any of the industries treated in the various chapters an attempt has been made to show in what way the same are related to the brewing and fermentation industries, and to suggest how the brewery might be adapted to the manufacture of the particular commodity. This is followed by a short exposition of the industry itself and for these expositions the Author is greatly indebted to the various collaborators, most of them specialists in the respective industry.

The profitable utilization of by-products, being of great importance at the present time, has been given special attention, and the complete bibliography of the more recent technical literature in conjunction with each chapter will save many hours for those wishing to acquaint themselves with a certain field and the present status of the industry.

The value of the extracts from the patent specifications can be illustrated in the case of non-malt and non-alcoholic beer like beverages. In the manufacture of these products, two points are of greatest importance and have caused deep concern, namely the employment of an inverting agent so necessary in the preparation of a non-malt beverage on the one hand, and on the other hand a means of producing a flavor which will simulate that of beer without producing alcohol. In looking over some of the patent specifications the reader will find a number of suggestions as to how a cereal mash might be converted without employing an expensive diastatic preparation. There are also a number of suggestions for accomplishing a fermentation in which the sugar is decomposed, without the formation of appreciable amounts of alcohol. The importance and value of these suggestions cannot be over-estimated, and while they require further research there is no doubt but that they will eventually lead to the development of practical process of great commercial value.

The Editor has been unable to include in this book all of the references of this nature in his possession and, therefore, considering these to be

of value, contemplates the publication of a companion volume, should the present book meet with a good reception on the part of those active in the industry. Inquiries by readers on any of the subjects dealt with are invited and whenever possible the same will receive personal attention.

Last but not least the Author would like to call attention to the first publication in this book of original research by himself in different fields which are herewith given to the trade without the expectation of financial returns. The Author is of the opinion that we have reached a stage where nothing short of sincere co-operation on the part of all men engaged in the industry will avert a calamity, and a free and unrestricted exchange of experiences, experimental results, and practical findings is the only way to accomplish this end.

The Editor takes this opportunity to thank all of those who have co-operated with him and who have supplied information or have given assistance in subjects in which they have specialized. The Author also wishes to thank the advertisers for their active support because they have made possible the publication of the book at a price sufficiently low so as not to work a hardship on any one. Special thanks is due to Mr. Carl Nielsen for his interesting article on the "Dairy Industry"; to Mr. R. A. Wittemann for his suggestions on the Utilization of Waste Yeast and the Bottling and Carbonating of the so-called "soft drinks"; to Mr. Aladar Fonyo for the Chapter on the "Manufacture of Compressed Yeast", and "Fruit Juices"; to

Mr. D. R. Sperry for information on the proper Installation of the Filter Press; to Dr. Leo Stein for the article on "The Manufacture of Ethyl-Alcohol"; to Mr. Paul Hassack for his contributions on "The Fermentation of Vinegar" and "De-hydration"; to Mr. George Defren for suggestions, and to Mr. William F. Carthaus for valuable advice, and to all others who have directly or indirectly assisted in making the book a success. The Editor is also indebted to his wife for assistance in the reading of the proofs.

The following authorities have been consulted and some cases drawn upon for authentic information: Leach: "Food Inspection and Analysis," Sherman: "Food Products," Brannt: "Vinegar," J. Murray: "The Chemistry of Cattle Feeding and Dairying," James Grant: "The Chemistry of Breadmaking," G. Martin: "Industrial Organic Chemistry," Thorp: "Industrial Chemistry," Kiby: "Presshefen-Fabrikation," and various scientific and technical journals.

In spite of the utmost care which has been exercised in the compilations and publication of the work it is needless to say that it has been impossible to eliminate all errors. The Editor will, therefore, be very grateful to have his attention called to any erroneous statements or serious omissions in order that they may be rectified in future editions. Suggestions from readers as to how the book could be improved so as to better serve all of those for whom it is intended will be thankfully received and given careful attention. CARL A. NOWAK.

St. Louis, Mo., June 15, 1917.

I. Introduction.

The Field.

THE problem which today confronts every brewer who has a material interest in the welfare of the brewing industry is the possible utilization of his investment in the event that through unfavorable legislation, his brewing plant as such will be forced out of existence. It is hardly possible to conceive in view of the transformations which have taken place within the last few years within the industry, that there still can be men financially interested in the same whose optimism is of such a pathological character that they are unwilling to see the fate which is bound to overtake them unless they assume an active part in the reconstruction and readjustments which public sentiment demands in order to attain social and industrial betterment.

The brewing industry as it has flourished in this country for the past three or four decades is doomed. The brewer, like the railroads has been permitted to accumulate wealth, to become a transgressor in the eyes of the public, and like the railroads has been the target for unfavorable legislation. But the acquisition of wealth, of property and political influence are not the only sins, of which, in the eyes of the people, the brewer has been guilty. His worst offense has been an utter disregard for public sentiment, due possibly in part to the desire to accumulate wealth, but more likely

to his lack of understanding of the principles underlying social progress and political economy. However, the harm has been done, reforms from within are at least ten years late, the force of the prohibition wave can no longer be checked, and for a number of years at least, the brewing industry will fare ill. There can be no doubt but that the brewing industry will eventually emerge victoriously from this period of reconstruction, and will then no longer be the object of constant attacks, but will be on a par with every other legitimate industry.

Only recently the District of Columbia has been added to the "Dry" territory, with the result that there are now twenty-three states in the dry column, and three others have elected governors and legislatures of such a character that the prohibition advocates are confident that they will follow the others in aridity.

It does not require lengthy arguments to convince the progressive element in our industry that we are actually confronted by a serious situation which must be met if our industry is to survive. It is only natural that the brewer feels an aversion toward the manufacture of "soft drinks" as they are popularly termed, because the manufacture, or compounding, of these beverages does not require scientific training and technical knowledge and he cannot help but realize that the many years of hard work which he has devoted in order to perfect himself in the Art of Brewing have been completely lost. This, however, is not entirely the case. If

the brewer enters the "soft drink" field and pursues methods equally scientific and perfected as he has been accustomed to in the past in the manufacture of his own product, he is bound to be successful and will, without doubt, eventually prove a menace, to the "soft drink" manufacturer who, either directly or indirectly, contributed his share to vote the brewer out of business.

The restrictions now placed upon the brewing business by political agitation bring home to the brewer the necessity of exercising every economy and saving possible in the brewing operation, especially in overheads, expenses and *wastes.* One of the principal wastes heretofore countenanced in breweries, simply because the utilization of the product remained unknown, is the surplus *yeast* after fermentation. When it is considered that approximately 4 lbs. of wet yeast are wasted from every barrel of fermenting beer, and that this yeast, when properly collected, treated and dried at a minimum cost, and that this dry material is a valuable food stuff, and that it possesses chemical properties and qualities which make it adaptable for many industrial uses, it must be apparent that it is worth saving.

Together with the pure albumen precipitated in coolship or wort tank, enough yeast can be collected to yield approximately 1 lb. of dry material per barrel of beer sold by the brewery, and hence a heretofore waste of approximately 60,000,000 lbs. in the United States per year is shown. It is asserted that this yeast can be dried at a total cost of 1c per

pound dry, which includes a safe percentage for amortization, and it is asserted that as high as 10c and 15c per pound has been obtained for this dry material. Consequently, if the total quantity of yeast could be collected, dried and sold, a minimum profit of approximately $3,000,000 a year has been thrown away.

Besides yeast and albumen, there is quite a considerable amount of excellent animal food stuff to be saved from the grains liquor, which is now run to the sewer from every grains press. This precipitate amounts to approximately 25% of the weight of the grains liquor, and can also be dried advantageously and quickly at very little expense on the yeast drying apparatus.

For the small brewery located in a dairying locality the conversion of the plant into a creamery, refrigerating plant, and possible ice cream plant has some inducements to offer. However, the complete utilization of milk and all of its products opens a much larger vista of possible commodities whereby the brewer could devote his undivided attention to just the one raw material, namely milk. If we wish to enter new fields of activity we must first decide upon what we wish to go into, and then go into it not superficially, but intensively. As brewers, we have been accustomed to manufacturing a high-class product in a scientific manner under the most sanitary conditions attainable. Whatever line of manufacture we may enter we should maintain our standard and aim to produce only what we know is wholesome and good, and produce it as scientifically as we know how.

When we enter upon the manufacture of any product dependent upon the dairying industry, we may safely say that we remain close to our chosen profession. The knowledge which we have accumulated as the result of years of experience of our beverage, which has many things in common with milk, has not been lost, moreover will enable us to grasp problems entirely beyond some of those now making a profitable business out of the dairy industry.

Whenever it is possible we should strive to manufacture one line of products only, and by thus concentrating all of our efforts on the improvement and perfection of this line, we will soon rank highest. However, not every product will permit of such an extensive utilization as is the case with milk. Not every product is of such a nature that its commercial exploitation will bring into play every department of the brewery and the bottle house, as is the case with milk.

In view of what has been said it is quite surprising why so very few of the breweries in dry territory have not devoted more attention to the possibilities of milk products as one way of profitably operating their plants. The Author, whose father has been a pioneer in the milk products industry in the United States, believes this to be due to the fact that the average person's knowledge about milk products is very limited and he is, therefore, unable to grasp the opportunities which lie in this field.

The conversion of the malt house into a manufacturing plant for the production of a commodity, or product, other than that for which it was originally intended presents infinitely more difficulties than is the case of the brewery. The malt house is equipped with very little machinery as compared with the enormous floor space and storage capacity to be utilized. The utilization of malting plants as elevators and warehouses is, of course, feasible but the earnings coming from such use will hardly cover the interest on the enormous capital investments. Some of our American malt houses have gone into the manufacture of feeding stuffs or rather cattle and dairy feeds. This industry is still in its infancy and most of the products of this nature now on the market which are sold at a high price and are valuable as stock feeds are manufactured by rule of thumb methods without knowledge on the part of the manufacturer of the principles which underlie scientific feeding. Even at the present time a large number of the by-products of the malt house such as chaff, malt dust and screenings are sold at a ridiculously low figure in spite of the fact that by means of proper milling and addition of other materials rich in proteins and carbohydrates to supply the deficiencies in these respects would result in a feed commanding a very high price per ton. Several years ago the Author recalls that the market value of chaff was about $4.00 per ton and he then made experiments mixing the same in proper proportions with other by-products so that the resulting mixture had a com-

mercial value of about $27.00 per ton. Another interesting case of industrial waste is that of malt sprouts originating from caramel malt. This material until a few years ago was utilized or rather wasted as a bedding and absorbing medium in stables, whereas an analysis showed that these sprouts owing to a high temperature at which they were dried and consequent low moisture content were possessed of a much higher food value than regulation brewers' or distillers' malt sprouts. It is true that they cannot be fed alone owing to their intensely bitter taste which is objected to by the cattle, but mixing and properly compounding with other feeds their market value at that time was about $24.00 a ton. From all of this it is evident that the malt house could be adapted to the manufacture of cattle feeds.

Another industry which is profitable is the manufacture of evaporated or desiccated fruits which, of course, is feasible only where the malt house is located in a fruit growing territory. The kilns are well adapted for this purpose and with the aid of the reliable engineer the necessary changes can be made.

As regards to manufacture of compressed yeast, it may not be out of place to mention that there are only 35 compressed yeast factories in the United States, distributed in the following states: four in California, one in Colorado, seven in Illinois, one in Iowa, one in Kansas, one in Louisiana, two in Maryland, two in Massachusetts, one in Michigan,

one in Missouri, six in New York, one in Rhode Island, two in Ohio, and three in Wisconsin.

As may be seen only sixteen out of the forty-eight states have their own yeast factories, and thirty-two of them are obliged to import yeast from the states. There should be a good field, therefore, in some of the states (not having any yeast factories at present) to start a factory locally with all reasonable prospect for commercial success. A good locally manufactured yeast, delivered in fresh state to the baker ought to stand competition with yeast transported from a more or less distant point, which upon standing loses its effectiveness.

Let us now see to what uses breweries located in states which have been in the dry columns for a number of years have been put to. In the state of Washington the brewing industry was thriving before the state went dry, and as a result there were numerous plants for which new uses had to be found. A former brewery in Aberdeen, Washington, is now canning clams; one in Spokane is manufacturing vinegar; in Olympia we are informed an ex-brewery is in the dairy products business; at Bellingham, Washington, the farmers have gotten together and bought a brewery which they converted into a co-operative creamery. The largest brewery in that state was formerly located in Seattle. We learn that this plant has worked out a process for producing a fine grade of table syrup from raw cereals and is changing its machinery and equipment to go into this new line of

business. It is also reported that denatured alcohol will be produced at this plant.

The commonest use perhaps to which breweries have been put in states which are already dry is for the manufacture of ice, or for cold storage warehouses. While this is not a very profitable utilization, only few changes are needed to make the buildings serve this purpose and for this reason, perhaps, this method of utilization appeals to many of the smaller plants requiring, as it does, very little investment. Packing plants also frequently replace breweries.

The manufacture of carbonated apple juice, loganberry juice, and other fruit juices put up in neat packages of glass so as to appeal to the eye, and retailing as low as 5c a bottle, promises to develop into a new industry of large dimensions. Several breweries in the West are now manufacturing and bottling such products which certainly do credit to the brewery producing them and to the man in charge of the operation.

From the above it is clearly evident that there are many uses to which the brewery could be put where this becomes necessary. As to how profitable these various undertakings will be, time only can show. We find ourselves only at the very beginning of a new era of industrial developments and to talk therefore from experience is practically impossible. We are, as it were, still groping in the dark and only too liable to over-estimate the possibilities which lie in a certain field. This statement is not made with the purpose of discouraging

those contemplating entering new industries but only to urge upon them the necessity of carefully investigating the resources and possibilities as well as the nature of the market before entering any of these fields. Even in the preparation of this book the main difficulty has been the lack of sufficient reliable data which would have made possible the presentation of the subject matter in a more logical and orderly manner. It goes without saying that there remains much to be desired, which in a part at least must be attributed to the fact that our industry is about to undergo a change and a development which has no precedent.

II. Low Alcoholic Beers.

By C. A. Nowak.

THE first attempts to prepare beer low in alcohol content date back to the time when the influence of prohibition began to make itself felt in this country. These attempts were further stimulated by the fact that according to the rulings of the Commissioner of Internal Revenue, beverages containing less than one-half of one per cent of alcohol could be sold by dealers without the necessity of securing a government license and in this manner a natural demand for products of this type was created.

In view of these conditions our scientific stations and brewing schools at that time took up the subject extensively, some of them even placing special courses in the preparation of low alcoholic beers upon their curricula. These courses were well attended, but for obvious reasons the various products, largely known at the time by the misnomers "temperance beers" or "non-alcoholic beers," did not seem to appeal to the public. While many of them continued to be made and were disposed of in limited quantities in prohibition territory, the novelty of the subject quickly wore away, and for a number of years following the subject was lost sight of, almost completely.

Today matters have changed again. If we will take time to look over the patent records we shall see at once that inventive minds have again busied themselves with the same subject, which, a number

of years ago, was considered stale and uninteresting. But a new phase has now entered and the problem at the present time is infinitely more difficult of solution. The legislation with regard to the manner of production and properties of these products is far more exacting than in the early days of low-alcoholic beers, largely because the laws enacted by different states and governing the manufacture and sale of these products are not uniform, and in order that his product may be salable in all states, the manufacturer has to comply with many regulations and limitations.

The various methods which can be employed in the preparation of the beverages dealt with in the present chapter, permit of the following classification:

CLASS I. Low alcoholic beers prepared in such a way that the alcohol content at no stage of the manufacture exceeds one-half of one per cent. (Checked fermentation.)

CLASS II. Low alcoholic beers prepared by dilution of a finished or partially finished beer with wort or water so that the percentage of alcohol in the finished product does not exceed more than one-half of one per cent.

CLASS III. Low alcoholic beers prepared by distilling off the alcohol from a finished or partially finished beer either under atmospheric pressure or under vacuum so as to reduce the alcoholic content to one-half of one per cent or less to suit the requirements.

CLASS IV. Low alcoholic beers prepared from

commercial extracts by dilution and requiring only very limited brewing operations.

CLASS V. Low alcoholic beers prepared by a combination of any or all of the processes specified under classes I to IV.

Low Alcoholic Beverages Belonging to Class I.

The main requisite in all of these beverages is that the wort contains a high percentage of dextrins and soluble non-coagulable albuminoids and a minimum amount of fermentable matter. It is, therefore, essential that the mashing operations be conducted accordingly. It is, furthermore, advisable and frequently necessary to augment the acidity of the unfermented wort in some suitable manner either by the addition of lactic, tartaric, or other similar acids, or by the addition of a small percentage of an auxiliary mash which has been permitted to undergo spontaneous acidification. The increased acidity will render the beverage more palatable, perhaps also more wholesome, and impart to it, to a certain degree, that peculiar snappiness which characterizes beer and which, without doubt, is due to the combined influence of alcohol and acidity, and conditions the gustatory sensations.

Practically all of the unfermented beverages may be said to lack the various aromatic esters which characterize beer and are the result of fermentation. In some cases the attempt has been made to supply these esters artificially but the results have been far from successful, perhaps large-

ly because of the complexity of these bodies which seem to defy imitation. In such cases where a small percentage of alcohol is permissible some of these esters may be supplied to a small extent by a process of checked or limited fermentation, materially improving the character of the beverage. Another process not infrequently resorted to is to boil the wort with a small amount of yeast, previously thoroughly washed with water, preferably water to which gypsum has been added, thus rupturing the cells and liberating the cell contents which seem to include a limited amount of these aromatic principles, but unfortunately also frequently bring into the beverage a small percentage of alcohol, and can be used only in such cases where this is not objectionable.

Another method by which acid and ester formation may be encouraged while at the same time the alcohol production can be greatly restricted is to oxidize a portion of the alcohol by means of a suitable chemical reaction into acids, simultaneously with its formation. This seems to be the basis of a process patented by Henry E. Deckenbach, who claims to produce a beer of low alcoholic content, by placing wort into a closed tub of yeast, admitting cooled oxygen under pressure upon its surface, permitting it to ferment and withdrawing the gases, this process being carried on to the desired stage.

R. Wahl has been granted a patent for the manufacture of beer of low alcoholic content, free from objectionable albuminoids and of a lactic acid con-

tent equivalent to the amount thereof contained in ordinary fermented beer, which consists in adding to the wort the acid extracted soluble substances of malt in solution, containing the peptase of the malt and the albuminoids dissolved and peptonized by its dissolving and proteolytic actions, and the acid used in extracting said malt; adding yeast to obtain the fermentation flavor; reducing the temperature of the yeasted wort nearly to the freezing point to arrest alcoholic fermentation and thereby maintaining the alcoholic content below one-half of one per cent; and causing the lactic acid to change the neutral phosphates of the wort to primary phosphates with sufficient additional acid to bring the amount of free lactic acid up to that contained in normal or alcoholic beer.

In the preparation of all beverages of the checked fermentation type it is customary to prepare a wort having a gravity of from 6 to 8 per cent Balling in the cellar and to ferment the same down until about 0.7 to 0.8 per cent of extract has been fermented away so as to give an alcohol percentage of not more than about 0.35. Care should be taken not to employ too large a quantity of yeast, one-half pound per barrel being, as a rule, quite sufficient.

When the desired amount of extract has been fermented it becomes necessary to check the fermentation. This can be accomplished either by chilling the liquid to the freezing point or by returning it to the kettle and there heating it to pasteurization temperatures. Some brewers even

boil the beer for about half an hour, thereby also evaporating a part of the alcohol. Where this method is employed it is, therefore, safe to permit the fermentation to proceed further, thereby gaining certain advantages, such for instance as more complete elimination of the objectionable wort taste. It is also advisable to add a small additional portion of hops about ten minutes or so before the beverage is run from the kettle.

Beverages of this type, and in fact all of the low alcoholic beers, can be materially improved by the addition of a small amount of common salt as well as gypsum. The extent to which such additions can be made depends largely upon the composition of the brewing water previously determined by analysis.

William O. Kaiser and George F. Stroebel of Burlington, Iowa, have been granted two patents which are of interest in this connection. The first of these consists of a process of producing beverages by treating the lautermash of the malt mash liquid with a catalytic agent, to convert the starch, dextrin, and maltose into glucose. The beverage is non-alcoholic and various acids and also ethyl acetate are finally added to impart to it the necessary zest and aroma. The various stages of the process consist in: (1) making lautermash by infusing ground malt with water and peptonizing same; (2) mixing ground cereals in water together with 2 per cent of "lautermash" to each barrel of water and peptonizing same for about 25 minutes at 30 degrees R., then boiling same for about 50

minutes; (3) adding to the remainder of the lautermash a small portion of a catalytic agent, and boiling same to convert the starch, dextrin and maltose into glucose, and cause the precipitation or brewing up of the amides, then neutralizing the acid; (4) adding the cereal mash liquid mixed with about 2 per cent of the lautermash to the residue of the ground malt; and quickly raising the temperature thereof to saccharify all the starch and convert the starch of the cereal wort into maltose and dextrin; (5) mixing the resultant cereal wort with the treated lautermash and about two pounds washed yeast per barrel and boiling the mixture for four hours; then adding about one-sixth pound hops per barrel to the mixture and continue the boiling for about ten minutes; (6) cooling the product and adding thereto a mixture of acetic, lactic and succinic acids and ethyl acetate in about the proportions in which they exist in beer, and digesting the whole for twenty-four hours; (7) finally cooling, carbonating and filtering the product.

The second above mentioned patent pertains to a process of making an unfermented base beverage consisting in making a mash of ground malt and water and heating same until it becomes peptonized; making a raw cereal mash of cereals and water and heating same; then adding part of the mash of ground malt to the raw cereal mash and heating same until the diastase converts the cereal starch into sugar; then adding the remainder of the mash of ground malt and boiling the mixture to stop further action of the diastase; then adding

to the mixture the residue of the ground malt and raising the temperature quickly to convert the starch into unfermented sugar; then separating the wort and boiling same; then adding about one-eighth pound hops per barrel to the mixture and boiling same; then adding about two pounds commercial yeast per barrel to the mixture and boiling same; then cooling the mixture, aging same, and finally filtering and carbonating the resultant liquid.

Low Alcoholic Beverages Belonging to Class II.

In general the objection to the products now on the market is that they possess the flavor and aroma of wort, are usually excessively hopped, and occasionally contain such an amount of unfermented but fermentable carbohydrates that if consumed in the same quantities as an ordinary light beer they will have a disturbing influence upon metabolism. According to the American Handy Book of Brewing and Malting (Wahl-Henius), the following dilution method is described as producing a beverage which will contain less than 0.5 per cent of alcohol: "The required quantities of beer, wort and water are mixed in a vat, partly carbonated, filtered, bottled and pasteurized as quickly as possible. If a beer of ¾ per cent Balling, produced from a wort of 12 per cent Balling was employed, the following mixture would produce a beverage with less than 0.5 per cent of alcohol kraeusen, 5 parts; beer, 7 parts; wort, 43 parts; and water, 45 parts. Another method is to mix a beer with a watery solution of dextrin in sufficient quantities to bring the

alcohol content to less than 0.5 per cent and the extract to about 5 per cent. The mixture is then chilled and carbonated. (Kraeusen may also be added.)"

Without actually preparing the beverage, it can readily be seen that the first method will give a product possessing the objectionable wort aroma and flavor previously mentioned; for the method of dilution is practically equivalent to diluting beer of ¾ per cent Balling with about 8 parts of water-wort mixture characterized by the absence of fermentation flavor. The second method is, in some respects, preferable. A dextrin solution produced from a high-grade product, and of the gravity mentioned, will possess "body" and contribute materially to the foam-holding capacity, and, moreover, is not directly fermentable and is free from wort flavor. Neither of these methods makes any provision for compensating the low acidity of the products, the character of which could be improved considerably by acidification in some suitable manner, with lactic, acetic or other permissible acid, so as to bring the total acid-content somewhat above that of a normal beer, and in this way imparting to the product a much more "snappy" flavor.

In the opinion of the Author most of the low alcoholic beverages now on the market have one common fault, namely they are too high in extract. A beverage of this type containing practically no alcohol but moreover an excessive amount of sugars or fermentable matters is very satiating and can be consumed only in small quantities. There are

numerous beverages on the market now which contain only from about 4.3 to 4.5 per cent of extract and which are very satisfactory products as far as palatefullness and foam-holding capacity are concerned. It is, of course, essential that all of these beverages be highly carbonated in order to endow the beverage with the requisite amount of snappiness, which in an ordinary beer is partially derived from its alcoholic content.

In a new process for which a patent was recently granted to the Author an attempt has been made to overcome some of the above mentioned difficulties. The product as prepared was free from wort taste and wort odor and in the opinion of a number of master brewers to whom it was submitted proved to be a very satisfactory beverage. Although protected by patent the Author has had no opportunity to introduce it on a large scale owing to his present connections and, therefore, has decided to give it to the industry without the expectation of any financial returns. Any master brewer is entitled to employ the method without any obligation whatever, and will possibly be able to modify it somewhat so as to produce a beverage superior to that which the Author has produced on a small scale. The following outline should give the practical man a good working idea of the method and should anybody wish any further information, it will be cheerfully given.

The above mentioned process differs in many respects from any of the known methods for preparing low alcoholic beers and other similar fermented

beverages. In the first place high mashing in temperatures are employed in order to obtain a maximum of unfermentable sugars and dextrins, a method now generally employed in the preparation of all low alcoholic beverages. The Author's beverage, however, differs from the usual methods employed in the following respects:

1. The use of a highly concentrated wort possessing a gravity of anywhere from twenty-five to thirty per cent Balling.

2. The employment of the yeast (top fermenting) containing acid forming bacteria, and capable of fermentation at high temperatures, which at the same time is conductive to the development of the aforesaid bacteria, and accompanying acid formation.

3. Fermentation temperatures from 73 to 95 degrees F., in open vats favoring the loss of alcohol and encouraging acid and ester formation, and the production of a vinous flavor.

4. Completion of fermentation within a short period, usually less that twelve hours.

5. Elimination of long storage periods.

6. Complete utilization of all raw materials and products of fermentation.

One of the advantages of this process is that by using the high pitching temperatures less refrigeration is required to cool the solution to the pitching temperature, and no refrigeration is required during the process of fermentation. Furthermore, owing to the high concentration of the mash a mash tub of only small dimensions is required. The same

holds with regard to the kettle and fermenting tubs.

Fermentation being completed in a few hours, this represents a great saving in time even over any of the customary top-fermentation systems. It also has the advantage that there is less danger of the development of foreign organisms, inasmuch as the high temperature and the acid formed by the acid bacteria which reproduce rapidly at this temperature exert a restraining influence upon the development of foreign organisms.

Fermentation at high temperatures brings about a vinous character, and the fermentation being conducted in open vats also hastens the partial loss of alcohol by spontaneous evaporation.

The process further brings about an economy in fuel, there being no prolonged hop boiling or concentration of wort, and no necessity for the evaporation of alcohol.

The sparging water employed for sparging the grains is also used for sparging the hops employed in the hopping of the heavy wort, and the whole liquor so obtained after being hopped is employed for diluting the fermented extract, thus resulting in a perfect utilization of all materials.

By the fermentation of a concentrated wort and only slight dilution with an unfermented wort or water there is obtained a beverage rich in fermentation flavor, heretofore impossible with any of the customary processes.

Kühn, in a patented process, makes two separate mashes, one to produce a wort containing the

maximum quantity of fermentable matter, which is then fermented, and the other under conditions insuring the transformation of starch into non-fermentable dextrins. The two liquids are finally mixed. Another process, not patented, yields a product quite as good as many on the market. In this, a strongly fermented wort of 6 per cent original gravity is mixed with a suitable volume of unfermented wort, or preferably second wort, carbonated and chilled under a pressure of 1½ atmospheres, filtered and filled off under a pressure of 0.6 atmosphere. If a product entirely free from alcohol is desired it is advisable to use a concentrated wort of about 50 per cent extract, diluting it tenfold with water, carbonating and finishing as usual. In either case the flavor is considerably improved by augmenting the acidity in a suitable manner.

In the preparation of malt beverages containing little or no alcohol it is advisable, for obvious reasons, to use a malt kilned off at a somewhat high temperature. The following process patented by E. Adam many years ago, should give a palatable beverage. Highly dried malt is mashed in and off at a high temperature so as to retain in the wort a high proportion of dextrins and a low proportion of maltose. The wort is mixed with hops and boiled down to a desired gravity and fermented, after which it is drawn off and allowed to mature and clarify in a suitable receptacle. It is then filtered from any yeast cells present, and kept in air-tight vessels until required. An unfermented wort, pre-

pared in a similar manner, but from highly cured malt, and of lower specific gravity, is mixed with hops, boiled down, cooled, left to stand and clarified as before described. These two worts are then blended in the ratio of 10/20 parts of the fermented to 80/90 parts of the unfermented wort, and the mixture is carbonated and matured. One of the difficulties in the preparation of these blended beverages of low alcohol-content is in maintaining absolute uniformity of the products, and in preventing an increase in the alcohol-content beyond permissible limits during storage.

Low Alcoholic Beverages Belonging to Class III.

The well-known method of removing the alcohol by evaporation or distillation, in some suitable manner which, since the recent ruling of the treasury department, is now feasible because it requires no longer the payment of the government tax on fermented beverages, in the opinion of the Author is one of the simplest and most efficient methods of preparing a product which is very similar to beer. Different modifications of this method are now employed with far greater success than in former years when this method was first suggested for the reason that the brewer has learned a great deal since that time and knows what conditions must be avoided. Until recently some breweries have been operating in such a way as to prepare a beer from a 12 per cent wort and then remove the alcohol by several hours boiling in the kettle. This, of course, is not only time consuming and extremely wasteful but

the resulting product will possess a very disagreeable boiled beer taste, which to a certain extent can be overcome by preparing a light original wort of about 7.5 per cent Balling using temperatures which are unfavorable to the formation of large percentages of fermentable matter and then permitting such a wort to ferment down to about 6 or 5.5 per cent Balling. By doing this practically all of the raw and undesirable wort taste and odor is eliminated and the fermentation, fairly complete, is checked by returning the beverage to the kettle and removing enough of the alcohol by boiling it until it has been reduced to the desired percentage.

Patents granted on the removal of alcohol from beer and wine, either partly or entirely, are quite numerous and only a few of them will be discussed here as representative of the working principles involved. It must be borne in mind that all of these installations represent a large outlay of capital, require large amounts of fuel and the process of itself is extremely wasteful and expensive, inasmuch as the alcohol produced at the expense of valuable carbohydrate materials has to be first produced, and then removed at an additional expense. There is no doubt, however, that the products prepared in this manner must be classed among the best tasting and most stable of the low alcoholic beers at present available. (See Chapter XI: Mechanical Appliances.)

As pioneers in this field, namely the reduction of the alcoholic content of finished beers, by evaporation in a suitable manner the names of Ernst

Uhlmann and Arvid Nilson deserve mention. Uhlmann perhaps was the first to appreciate the demand in certain of the prohibition states for a beverage possessing the essential properties of beer but of such a low alcoholic content that its sale would be sanctioned by the laws of the respective states. Accordingly his practical experiments in this direction resulted in the development of a new process of brewing, patent for which was granted to Uhlmann on November 8, 1898.

Speaking of his process in a personal contribution to the American Brewers' Review, Mr. Uhlmann writes in part as follows:

"The process consists in boiling the alcohol from the beer produced in the ordinary way, cooling the boiled beer, adding a small percentage of kraeusen or sugar and yeast, carbonating, chilling, and finally filtering same.

I expected a small royalty from brewers licensed to use my patent; but the brewers could see no reason for paying a royalty, no matter how small, when they thought they knew, through the patent letter, how to make the beer. And the country is now flooded with such beers, made according to my patent. Some are better, some not as good.

Almost invariably my imitators made two mistakes. The first to my mind, is a very important one, the second affects the quality of the product.

1. Most every one of these beers is classified as a temperance beer. This is wrong, as all beers are temperance drinks, and if a brewer himself calls this new product a temperance beer, the layman is

led to believe that the regular beer is not fit to be drunk by a temperate drinker, and much harm is thus caused. The beers according to my patent and similar processes are non-intoxicating drinks.

2. During fermentation not only carbonic acid gas and alcohol are formed, but also aromatic products, which give to the beer much of its character.

If, by applying heat, beer is de-alcoholized, water, carbonic acid gas, the above mentioned aromatic products and alcohol are evaporated. The gas and so much of the alcohol as desired, are restored by the addition of the kraeusen, or sugar and yeast, through the second fermentation. The aromatic products are produced in proportion to the amount of fermented sugar, but the amount of sugar to be fermented is governed by the amount of alcohol desired.

The brewer making non-intoxicating beer, boils the beer for a certain time, say one, two or three hours, evaporates some of the water, all the gas and all the aromatic products and in most cases only a part of the alcohol. With some of the alcohol left in the beer, he can add only such a very small amount of kraeusen that the resulting fermentation does not form enough aromatic products. In many cases there is so much alcohol left in the boiled beer that even the smallest addition of kraeusen produces too much alcohol, and so few aromatic products that the beer has lost its character as such, and because of too much alcohol cannot be sold legally in dry territory. To overcome this difficulty water is added, the alcohol so reduced to the amount legal-

ly allowed, and the drink becomes, as stated above, sometimes good and sometimes bad.

To evaporate the alcohol, beer should not be boiled for a length of time, arbitrarily set by the brewer, but should be done the following way:

A certain amount of barrels are run into the kettle, heated to boiling point and allowed to boil until one-third of the volume is evaporated; then cooled and water added till the original volume is reached. After thoroughly mixing, the kraeusen are added. Most brewers will say this might be theoretically right, but practically impossible, because if in the ordinary beer kettle 100 barrels are boiled down to about 66 barrels, so much money is spent for coal and labor that no profit is left for the brewer.

This objection may be easily overcome since it is really not necessary to bring the cold beer into the boiling kettle, as is done generally, and so waste considerable time and coal in bringing this liquid to the boiling point.

My suggestion would be to pump the cold beer through an exhaust heater, so that it arrives at about 210° F. on the discharge end, and arrange the discharge so that the heated liquid falls through the air into the kettle.

If the brewer will do this he will find that all the alcohol will be evaporated without using any excessive amount of coal and labor.

With all the alcohol removed the second fermentation can easily be so arranged that only the amount of alcohol legally allowed is formed, as

well as the necessary amount of aromatic products, to give the non-intoxicating drink a beer character."

A few years later Nilson experimenting along the same lines as Uhlmann proceeded in much the same manner with the exception that he conceived the idea of fermenting the wort unhopped, and then boiled it with the addition of hops which at the same time was instrumental in removing a portion of the alcohol, the amount evaporated, of course, depending upon the duration of the boiling.

While both of these processes are extremely simple and require no change in the brewing equipment, they unfortunately have a very serious drawback. Whenever alcohol is evaporated from beer by boiling at atmospheric pressure, the aromatic esters which impart to beer its specific character are likewise lost and besides boiled beer unfortunately acquires during the process a peculiar taste, frequently referred to as "bread taste" and sometimes also induced in bottle beer as a result of over-pasteurization or subjecting the beer to excessive pasteurization temperatures.

While the work above mentioned has laid the foundation to all further researches in this direction, attempts were soon made to overcome, by some suitable means, the two main drawbacks attaching to the boiling process, namely development of bread taste as a result of the high temperature, and loss of esters owing to their volatile character.

To overcome the formation of the off-taste of boiled beer seemed a matter of relative simplicity, all that was thought necessary being to work with

reduced pressure, resulting in the lowering of the boiling point of the liquid. This can easily be accomplished with the aid of a vacuum pan, or vacuum evaporator, and using a sufficient vacuum that the ebullition of the liquid may take place at lower than pasteurization temperatures. However, practical experiments showed that while a far more satisfactory product was obtained in this way, the results were not what they were expected to be, and it was later found that the long time required to effect the removal of the alcohol even with the aid of the vacuum, and the maintenance of the beer at a fairly high temperature during that time, was the source of the trouble. The phenomena was similar to that of over-pasteurization. As a result it was found necessary to not only remove the alcohol under reduced pressure but to do so *rapidly*. Accordingly various means were devised, such as distributing the beer in a fine spray over large heated surfaces, passing heated air or carbonic acid gas through it, or exposing large surfaces to the air by immersing sheets of absorbent materials partly in the liquid and depending upon capillarity to do the rest, etc. In almost every case special patented apparatuses have been devised for the purpose and it is the intention to explain a few of them in greater detail.

The second problem, namely the preservation of the volatile esters in the finished product, is far more difficult of solution. One way to accomplish this is by means of a rectifying still, such as is used in the distillery for the rectification of spirits.

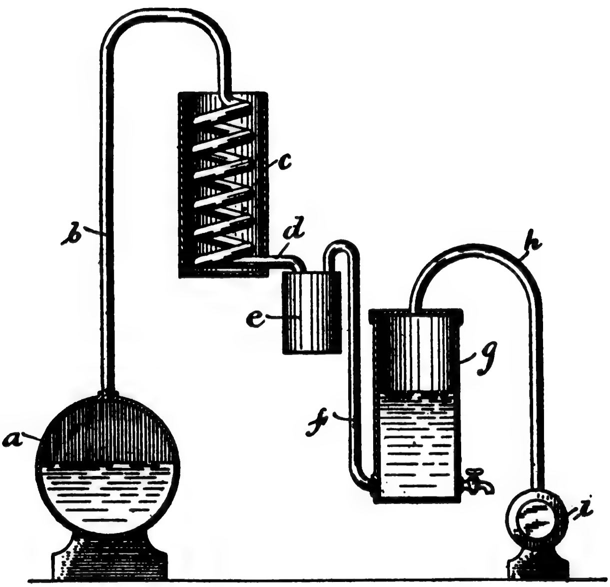
However, a still of this sort is a valuable piece of machinery and represents a big outlay of capital. A simpler method requiring less complicated machinery has been devised by Carl Jung, who was granted a patent on his process about three years ago. The seeming simplicity of the process and clear exposition of the principles involved merit for the same a somewhat more detailed account, which is based on the patent specification.

The invention relates to improvements in the dealcoholization of naturally fragrant or of aromatized alcoholized beverages including all wines from grapes, fruit, berries and the like, also beer, and the object of the invention is the production of a non-alcoholic beverage having all the natural appearance and flavor, and in case of wine even the fine bouquet of the natural or original beverage and affording the same enjoyment, but without the exciting effects due to alcohol.

The disadvantage of processes heretofore used, having similar objects in view, resided in the fact that the pleasant odors and perfumes or aromatic constituents, which give the beverage in its original or natural state, its character, are permitted to distill off with the alcohol with which they are collected and condensed. In this way the aromatic constituents being conducted into the alcoholic distillate and retained therein, the beverage, the subject of the treatment while freed from alcohol, loses its bouquet and becomes insipid, in no way resembling the original beverage. This difficulty is overcome by separating the substances having

those pleasant odors from the alcohol contained in the beverage and restoring such substances to de-alcoholized liquid, without permitting them to collect in the alcoholic distillate.

When the vessel *a* (See Figure) has been filled



with the beverage the air-pump *i* is operated and at the same time the beverage is heated, the air-pump exhausts the air contained in the apparatus. The gradual heating of the beverage, and the simultaneous diminution of the atmospheric pressure cause the volatilization of those substances which volatilize at low temperature, such as ethyl aldehyde and acetic ether. These substances are

carried over with the current of vapor passing through the conduit *b*, the worm-pipe *c* and the elbow *d* and arriving in the receptacle *e* from which they pass through the pipe *f* and enter the vessel *g*.

The vessel *g* contains a liquid of the same character as that being treated in the vessel *a* except that its alcohol content has been previously removed and that there is preferably added to it or mixed with it some syrup of sugar. This liquid takes up and absorbs aromatic substances. When the contents of the vessel *a* are at boiling point, which will depend in part upon the degree of exhaustion of air, the alcoholic and aqueous vapors ascend together with the aromatic substances which constitute the flavor or other characteristics of the natural beverage. As the alcoholic and aqueous vapors are heavier and less volatile and therefore quicker in changing from the gaseous into the liquid state they are the first to condense and they settle in a liquid state on the cool sides of the condenser worm *c*. To bring this about the temperature in the condenser is controlled so that the said condensed alcoholic matter will be received in the receptacle *e* and remain therein. The aromatic vapors, however, proceed, unaccompanied by the alcohol, because they require a considerable lower temperature for their condensation, until they arrive in the vessel *g* where they are absorbed by the mixture aforementioned, this absorption being favored by the low temperature which the aromatic vapors have acquired during their passage through the apparatus described.

When the distilling process as described has been

completed, the de-alcoholized beverage in the vessel *a* may be cooled and mixed in proper proportion with the whole or part of the aromatic mixture contained in vessel *g*. It may then be filtered (which should be done under exclusion of the air), impregnated with carbonic acid gas, bottled and pasteurized. The beverage thus obtained is of a pleasant taste and smell and may be preserved in bottles for years.

It will be seen that the novel features of this invention thus depend upon the maintenance, during distillation, of conditions which will cause the alcohol to condense itself out of a mixture of vapors while the remaining vapors are passed on to a further vessel wherein they are condensed in the fluid in which their properties are to be employed. In other words, the de-alcoholization process consists in not only removing the alcohol but several other constituents thereof, and then by suitably extracting the alcohol from a mixture of vapors and returning the balance of the vapors to what is left of the original beverage, de-alcoholization is accomplished without sacrificing any material part of the remaining properties of the original liquid; and by adapting the particular method described it is possible to conserve practically the entire quantity of aromatic ingredients without any interruption during the distilling process.

Among some of the other interesting patents for facilitating the removal of alcohol is that granted to Donato Cozzolino of San Diego, Cal. (U. S.

Patent 1,082,411), the object of which is to provide an improved evaporating apparatus arranged to facilitate the evaporation of a liquid by the use of suspended surfaces having their lower portions extending into the liquid, and having their upper portions above the level of the liquid, so that in case the liquid is fed into the vessel from above, it flows down the surfaces and hence readily evaporates, and in case the surfaces are of fabric material the liquid contained in the lower portion of the vessel passes up the surfaces by capillary action.

According to specification, heat but no vacuum is employed to effect the evaporation. The idea seems a clever one but the practicability is extremely doubtful, especially as far as beer is concerned proper cleaning and sterilization of the enormous surfaces of the fabric material appears almost impossible.

A process which appears more feasible has been worked out by O. Overbeck and since March 10, 1914, is protected by U. S. patent 1,089,862. The object of the present invention is to de-alcoholize various liquids without submitting them to a boiling process and without the employment of a vacuum pan.

By means of this invention liquids may be de-alcoholized and the alcohol may or may not be collected. Whether or not the alcohol is collected depends to some extent upon the nature of the liquid under treatment. Thus when beer is treated the object is to obtain a non-alcoholic beverage and the alcohol generally speaking will run to waste,

but when distiller's wort is treated the alcohol will be collected.

In the specification of the patent the inventor makes the following statement:

"According to the present invention I place the liquid to be treated in a number of closed tanks, preferably of various heights, the bottoms being arranged one slightly below the bottom of a next adjacent tank. Carbonic acid gas at a pressure of about 2½ pounds per square inch is caused to enter the lower part of the first tank, it passes up through the liquid in the lower part of that tank and escapes at the upper part of the tank. It is then conducted to the lower part of the second tank and passes up through the liquid. The carbonic acid gas thus passes up through all the tanks and blows all or nearly all the liquid into froth. Means are provided for ascertaining the height of the froth in the last vessel so that it may be prevented from passing out of the tanks. The carbonic acid gas, after it has left the last tank, passes through a cooling coil and then into the water contained in the lower part of a gasometer and rises through the water into the upper part of the gasometer, whence it is caused to pass through coils where it is warmed previous to again entering the first tank, the process is thus a continuous one, the gas being used time after time until the required amount of or all alcohol is removed from the liquid.

"When treating distillers' wort the liquid is warmed to about 90° F. in an atmosphere of carbonic acid and I then commence to pass the gas

through it. The heating is continued until the temperature reaches about 170° F. During the whole of this time the gas continues to pass through the liquid. Beer, however, is not raised beyond 120° F.

In the main this process consists in first placing the liquid under a slight and positive atmospheric pressure, then replacing with carbonic acid gas any air which there may be in the receptacle containing the liquid, then raising the temperature of the liquid to about 90° F., then blowing the liquid into a froth by passing carbonic acid gas through the liquid in sufficient quantities and continuing the same until the liquid has been de-alcoholized to the desired extent, then cooling the mixture of carbonic acid gas and alcohol, and finally passing the said mixture through a body of water which absorbs the alcohol therein.

The essential feature of U. S. Patent 1,171,306 granted last September to Becker & Montgomery lies in the spraying of the beer in an atomized condition over a heated conical surface arranged somewhat in the manner of a wort cooler. This process requires no vacuum and appears fairly simple and inexpensive. Those interested might do well by writing for the patent specification. According to one of the claims the process consists in raising the temperature of a charge of the beverage to not over 167° F., then spraying the charge into a sheet and subjecting the sheet to substantially the same temperature to permit it to give off its alcohol, then collecting the charge and raising it again to sub-

stantially the same temperature, then repeating this process, and finally cooling the product and conducting it to a point of storage.

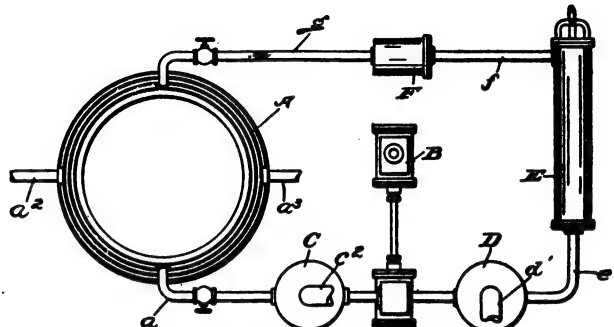


Fig. 1.

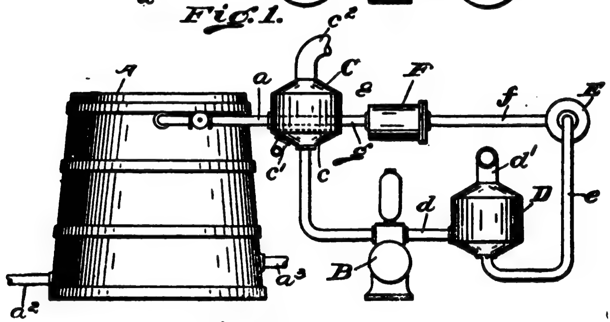


Fig. 2.

Figures 1 and 2 (above) are the plan view and elevation respectively, of an apparatus patented by Deckenbach (U. S. Patent 1,017,086, Feb., 1912) for removing alcohol, albuminoids, and impurities from beer and of aerating and cooling it. The inventor claims that his invention consists in withdrawing beer from the fermenting tub, passing heated, compressed air through it, carrying off the

air, sending the beer through a cooler, then carrying it through a strainer to the fermenting tub, and continuing the circulation until the beer has been lowered to the desired temperature.

According to the specification the method of procedure is as follows:

Wort at a temperature of about 45° F. is drawn into a fermenting tub, A, from the hop-jack, where it has received about 12 per cent extract. In the tub it receives its yeast and the fermentation which then commences is allowed to proceed to any degree desired, such as until it contains about 6 per cent extract. It will then be found to have risen to about 54° F. The beer is then drawn off from the tub, A, through pipe, *a,* by the pump, B. In the pipe, *a,* between the tub, A, and the pump, B, the vessel, C, is interposed. Vessel, C, below the point at which the pipe, *a,* enters, has a strainer, *c,* below which a pipe, c', enters the vessel, C. Through the pipe, c', treated air under pressure and at a temperature of 140° F. is injected. This heated air passes up through the beer as it flows upon the strainer, *c,* absorbs the alcohol in the beer and passes off through the pipe, c^2. This alcohol-laden air may be allowed to escape into the atmosphere, or may be led from the pipe, c^2, into a condenser for recovering the alcohol. Treated air is that which passed through the mercury. The beer is forced by the pump, B, through pipe, *d,* into a cold air vessel, D, thence through pipe, *e,* through cooler, E, thence through pipe, *f,* through strainer, F, thence through pipe, *g,* back into the fermenting tub, A. A pipe,

d′, enters the vessel, D, to supply compressed air of a temperature of about 32° F. thereto. The pressure of the cold air is made somewhat greater than the pressure of the liquid entering the vessel, D, from the pump. The purpose of adding this treated, cold air to the liquid is to assist in clarifying it when the liquid is drawn from the fermenting tub to the chip cask, not shown. Because it has been cooled in the vessel, D, the beer when it enters vessel, A, will cool its contents and assist in precipitating albuminoids. In passing through the cooler, E, the beer is lowered to a temperature of about 29° F. The strainer, F, retains any yeast cells, albuminoids, or other impurities. The circulation of the beer is continued until the liquid in the fermenting tub has reached a temperature of about 32½° F.

When the process is used upon a beer which has undergone what is termed a "full fermentation," before withdrawing the beer through the pipe, *a*, as aforedescribed, the fermentation is allowed to proceed until a test of the beer indicates that there is remaining about 2½ per cent extract therein.

After undergoing the process, the beer is withdrawn from the tub, *a*, by the means of a pipe a^3, and the yeast may be withdrawn through pipe, a^2. By this process the alcohol in the beer may be reduced to less than one-half of one per cent.

Low Alcoholic Beers Belonging to Class IV.

Perhaps the simplest and most certain of methods, especially well adapted to the smaller plants,

are such as are dependent upon the employment of an extract which can be bought on the market and which forms the basis of the beverage. Such extracts are now prepared by different concerns, one of these called "Multiplexine" is prepared by an Eastern laboratory, another one by the Wallerstein Laboratories in New York, still another by the "Brewers' and Distillers' Laboratories" in Chicago. This is by no means a complete list but merely those which came under the Author's personal observation and manufacturers of other extracts not mentioned would do well to communicate this fact to the Author who will keep their names on file, should he receive inquiries from any master brewers who would like to do some experimenting with such extracts.

The Fresno Brewing Co., of Fresno, Calif., of which Mr. William J. Eilert is president, C. Sayer, secretary, and S. J. Heiberg, superintendent and master brewer, are perhaps the pioneers in producing a beverage which has as its basis an extract of this type. The Fresno Brewery's product has been a marked success and while it is a departure from the general type of a low alcoholic beverage it has been very favorably received. The extract used in the manufacture of this beverage is the product of the Pacific Extract Co., of Fresno, and that it is a success is evinced by the fact that it is now employed by fourteen breweries in different parts of the United States.

General Considerations.

It is needless to enter further into a discussion of beverages falling in Class V, inasmuch as these consist of any or all of the processes already enumerated which can be employed in an endless variety of combinations.

Attention has already been called to the fact that in the preparation of low-alcoholic beers, especially where only a small amount of malt is employed, original worts of low gravity should be used because a more dilute mash is more easily saccharified. In all of these beverages considerable difficulties are encountered in the draining or filtering of the wort owing to the absence of adequate filtering material, which to an extent can be overcome by the addition of malt sprouts or malt husks shortly before the wort is drained from the mash tub, as otherwise these are liable to impart an undesirable taste to the beverage. Non-malt beverages prepared from raw cereals necessitate the employment of the filter press to effect filtration which is impossible in any other way owing to the absence of any natural filter bed. The proper installation and operation of the filter press is further described in Chapter XI, which deals with mechanical appliances.

Regarding the advantages which are to be obtained by holding the mash for a considerable time at peptonization temperatures it would seem in the light of recent experiences that these have been grossly over-estimated. The value of peptonization resides almost entirely in the formation of acid at this temperature, which is instrumental in decom-

posing the phosphates. To overcome the effect of hard water it may be well to add at this stage a small amount of an auxiliary acid mash such as is used in the distillery. This manner of procedure will take care of the phosphate with the necessity of holding the mash at peptonization temperature and will also indirectly assist in obtaining a higher yield of extract from the materials employed. Bearing this in mind it is entirely satisfactory when mashing for low-alcoholic beverages, judging from the results which have been obtained in this way, to mash in at a temperature of 57° to 60° R. and to rapidly saccharify the mash at this temperature.

The wort as it runs into the kettle should be practically free from matters in suspension, and if this cannot be obtained by the ordinary method of draining the mash, it will be money well invested to install a filter press for the reason that a wort from which all coagulated materials have been thoroughly removed prior to the boiling of the same will be much more free from the objectionable wort taste, which it is otherwise almost impossible to overcome. We have also already spoken of the addition of lactic acid, sodium chloride, gypsum and also washed yeast in the kettle. All of these natural ingredients of the beverage will work wonders if judiciously employed. Addition of foreign materials such as liquid quassia or saponin to produce foam, gum arabic to supply body, and meta-sulphite of potassium should be positively avoided and must be condemned for obvious reasons. While K. M. S. is an efficient

preparation for the prevention of after fermentation it is nothing more than a chemical compound which should not be permitted to enter into any beverage. Oxalic acid has likewise been used for this purpose especially where a beverage containing fermentable matter is shipped in wood, but owing to its poisonous character its use is to be objected to far more than that of sulphite.

For augmenting the acidity of a low-alcoholic brew not otherwise acidified in the cellar it is customary to use tartaric, and sometimes a combination of tartaric and citric acids. Tartaric acid may be safely used, but the amount must not exceed one pound per one hundred barrels.

A beverage in the cellar which is practically free of alcohol, that does not contain more than about one-tenth of one per cent, can be materially improved by blending with some fully fermented beer not to exceed five barrels per one hundred of the beverage.

Before concluding it may not be amiss to say a few words as to the removal of the alcohol by means of evaporation either at atmospheric conditions or under vacuum. Some of the apparatus for this purpose which have been mentioned in the preceding pages consist of elaborate and expensive machinery and have been patented, thereby obligating the brewer to pay a royalty on their use. With the assistance of a capable engineer any brewery possessing a pressure cooker should be able to convert the same with a very small outlay into an apparatus for

the de-alcoholization under reduced pressure. The vacuum necessary can be obtained either by means of a pump or a jet of water, and in either case will permit of the removal of alcohol from a beverage at a rate approximately four times as fast as is possible in the kettle. Not only is there an appreciable saving in the time of boiling, but the beverage does not suffer nearly as much in point of taste as when boiled at the higher temperatures. The main considerations in the removal of the alcohol from beer are, in the first place, that the beverage be subjected to a high temperature for only a very short period, and in the second place, that the process be a continuous one so as to require little attention and to insure uniformity of product. Suitable evaporators for the removal of alcohol can also be obtained from the Swenson Evaporator Co. and the Zaremba Co. (see advertising section), who will be glad to go into details with any interested party.

Attention is called to the graphic chart here appended, which may be of service to anyone wishing to survey the entire field of low or non-alcoholic beverages.

Graphic Chart for Low and Non-Alcoholic Beverages.

Materials: Raw cereals, malt (preferably a high dried pale malt if much is used), special sugars low in maltose and high in dextrine and dextrose, extracts, or extract bases.

Concentration: Usually between 6 to 8 per cent Balling.

Mashing Temperatures: High, to avoid formation of excessive amounts of fermentable sugars. Long peptonization not necessary. Addition of acid auxiliary mash advisable. Insure good filtration. Do not sparge excessively.

Inverting Mediums: Diastase obtained from low dried, high diastatic malt substitute for non-malt beverages. Twelve per cent good high diastatic (distillers') malt will invert a grain mash. Malt hulls. Malt sprouts. Artificial or commercial diastatic preparations expensive.

Kettle Operations: Addition of washed yeast preferably washed in gypsum water, about 1 lb. per barrel. Addition of lactic acid (unless previously added in the mash) and sodium chloride. Addition of Burtonizing salts. Hops, about one-third pound per barrel.

Cellar Operations: Keep at low temperature, preferably at 0° R. Prolonged storage modifies the harsh taste of the hops. Addition of chill-proofing compound (Wallerstein) or employment of Wahl's lactic liquor method.

Acidity: Can be augmented by addition of lactic acid in kettle of tartaric acid in cellar not more than 1 lb. per 100 barrels.

Pasteurization: Employ temperatures somewhat higher than in pasteurization of bottle beer. About 160° F.

Removal of Alcohol: Preferably under partial vacuum. Process should be continuous and beer exposed to high temperatures for short period only. Beers should be brewed in light in gravity and preferably completely fermented. If alcohol is completely or nearly completely removed, the product can be blended with real beer, using not more than 8 barrels of real beer to 100 of de-alcoholized beer.

III. Non-Malt Beverages and Fruit Juices.

By C. A. Nowak

NON-MALT beverages may be divided into two general classes, namely, beer like beverages manufactured along similar lines to beers low in alcoholic contents by replacing the malt by some other suitable inverting medium, and fruit juices.

In the previous chapter we have discussed in more or less detail some of the customary methods employed at the present time for the manufacture of low alcoholic beers. Practically all of these methods can be so modified as to permit the manufacture of a very similar product either without malt or by using only a very small percentage which ordinary chemical analysis will fail to detect in the finished product.

The main obstacle met with in the preparation of non-malt beverages is the selection of a suitable inverting medium. Various diastatic preparations now on the market, such, as for instance, *Taka Diastase* are too expensive to permit of employment on a large scale. These preparations have the further disadvantage that in cases where they are used there is a lack of protein bodies and consequently a lack of palatefullness and foam-holding stability and it therefore becomes necessary to add besides this enzyme some matter which will supply the necessary amount of protein.

The well-known laboratory method of preparing

fresh and quite active enzymatic precipitates by means of the addition of certain salts to cold water malt extracts could also be employed on a large scale but the process is a very laborious and time consuming one, requiring special machinery and utmost care. The precipitates obtained in this way are in a highly impure state and contain besides the diastatic and peptic enzymes a large number of other nitrogenous substances, among them amides and amino acids which in themselves are desirable and will contribute considerably towards foam and foam-holding capacity.

It is indeed fortunate for the brewer who is obliged to manufacture maltless beverages that most of these beverages have for their starting point a wort of low gravity, because if such were not the case the removal of the grains from the wort would be next to impossible. Even where the mash is very dilute its proper filtration presents considerable difficulties and practically requires the installation of a filter press and the employment of kieselguhr and similar filtering mediums employed in other industries where slimy liquids demand filtration.

Where this is at all possible a beverage can be manufactured by employing as little as 10 per cent of malt provided the malt is of the character usually bought by distillers, and known as distillers' malt and which is a low died malt of superior diastatic power. It is questionable whether a beverage in the manufacture of which no more than the above mentioned percentage of malt has been employed can be considered a malt beverage. As a matter of

fact malt has not been used as a raw material but merely as an agent to accomplish a certain end, namely the conversion of starch into sugar.

As already stated the malt best suitable for this purpose is distillers' malt. This material has the advantage that it can usually be bought at a lower price than a good grade of brewer's malt. It is entirely satisfactory to employ grain which may appear somewhat dark and is very small berried. As a matter of fact the lighter grades of barley which appear to be inferior are capable of yielding, if properly malted, malts possessing a much higher diastatic power than such prepared from large berried barleys.

Where it is desirable not to use any malt at all the experiments of the Author have shown that the malt husks from which the flour and grits have been separated by mechanical means such as by screening, if used to the extent of about 30 per cent are capable of effecting complete saccharification of a not too concentrated cereal mash. These experiments were made some three years ago while the author was still connected with one of the largest malting plants in this country. At that time this property of the hulls, namely their starch inverting power, was of relatively small importance as compared with today when so many states legislate against the beverage resembling beer in which malt has been employed. Applications for letters patent covering the employment of malt hulls as a filtering and inverting medium have recently been filed.

In order to eliminate as far as possible the diffi-

culties arising from the lack of a proper and cheap inverting medium it is customary in the preparation of practically all non-malt beverages to replace as much as possible of the starchy materials by sugars high in dextrins and low in maltose, in other words sugars or syrups possessing a minimum of fermentable matter. One such sugar is lactose which is practically unfermentable.

Sugars alone, however, will not make a beverage and it is necessary to employ in connection with them some material of a nitrogenous character in order to supply protein which our past experiences would indicate is absolutely essential to foam-holding stability and palatefullness. A method whereby yeast is employed to supply the deficiency has been suggested by Siebel as published in the "Communications" of the Master Brewers' Association of the United States Vol. XXI, pp. 141. Another process has been patented by John Beerhalter and C. Ringler and will be mentioned in more detail later.

Recently the Author had some correspondence with Mr. George Defren, who has been granted United States Patent No. 960,841 on the preparation of beverages, the object of his invention being to add milk sugar or lactose to a low alcoholic or non-alcoholic beverage, in order to increase the amount of extract in it, however, without introducing into the beverage an additional amount of fermentable matter, which, in a low alcoholic beverage is always objectionable. Mr. Defren writes that the average brewer will ridicule the idea of applying milk sugar in the brewery and, therefore, has

not done a great deal with his patent. In the Author's opinion his suggestion is a very good one, milk sugar is a very good raw material for the manufacture of any food product and the question as to whether it can be favorably applied in the brewery in the manufacture of beverages of the above type remains to be seen and can be proven only by actual experiment.

Milk sugar, unlike the other carbohydrates with which the brewery is more or less familiar, is not decomposed by the common beer yeast. Thus, according to Defren, it is apparent that if any fermentable sugars be present in the beverage the amount of extractive matter remaining unfermented (including the entire amount of milk-sugar added) would be largely increased, thus rendering the liquid more palatable. For example, a malt wort of approximately 12 per cent extract was made in the usual well known manner and divided into three equal portions. The first portion was fermented in the usual manner. To the second portion was added twelve pounds of milk sugar per eighty-eight pounds of water, or 12 per cent, thus making the total gravity about 24 per cent. This portion was then also fermented. The third portion was prepared as was the second, but modified by adding one litre of water to one litre of wort, in other words, diluted one-half; this was also fermented, and the resulting beers analyzed for alcohol and "extract" with the following results:

	No. 1 Pc.	No. 2 Pc.	No. 3 Pc.
Original gravity about	12	24	12
Alcohol finished beer	3.6	3.5	1.9
Extract in finished beer	4.9	.17	8.3

It will be noted that in the finished beers, the first and the second contain practically the same amount of alcohol, while the third contains about one-half as much alcohol as do the first and second. It will be noted also that the second, with the same amount of alcohol as the first, contains much more extract than does the first. This is due to the milk sugar added, none of which has been decomposed during the process of fermentation. It is likewise evident from an inspection of the third portion of the fermented wort, where, with the same initial gravity as the first portion, the finished beer gave about half as much alcohol and a much larger extract, this result likewise being due to the unchanged milk sugar. A comparison of the three portions indicated therefore, that the ratio of the percentages of alcohol to extract can be very easily controlled by the addition of milk sugar.

A new type of product which is gaining favor consists of an alcoholic concentrate or extract, often syrupy, which requires only to be diluted with carbonated water and bottled. The stringent laws enforced in some of the American states, prohibiting the use of malt for the preparation of beverages, have led to the production, from other materials, of beverages having the appearance of beer and a somewhat similar flavor. One such process, patented by Hoelldampf, is carried out as follows:

Twenty-five litres (5.5 gallons) of an aqueous hop extract, made from 1 lb. of hops, are mixed with 50 litres (11 gallons) of matured cider, 12 litres (2.6 gallons) of apple juice, and 8 litres (1.8 gallons) of a solution of 1 lb. of sugar in 1¾ pints of water. The mixture is forced through a filter under a pressure of carbon dioxide, mixed with 155 litres (34 gallons) of water and carbonated with 7 lbs. of carbonic acid. The apple extract employed is prepared by concentrating the expressed juice of fresh apples (preferably rennets), coloring it slightly with burnt sugar, adding a small quantity of tartaric acid, and diluting 3 lbs. of the liquid to 12 litres (2.6 gallons) with water. The keeping qualities of the beverage prepared by this process may be enhanced by pasteurization. In appearance and foam-holding capacity the product is indistinguishable from light lager beer. It contains 0.6 to 1.5 per cent of alcohol, and on exposure to air turns stale, like beer. Turbidity can only be caused by yeast ferments in the cider. The Author considers that fruit extracts may in future find extensive use in the preparation of beer-like beverages.

John Beerhalter and Chas. C. Ringler were granted a patent on a method of extracting and modifying protein or albuminous matter from substances containing it, and is particularly adaptable to the extraction and modification of protein or albuminous matter from yeast cells.

Although the description of the method is specific as to the extraction and modification of protein from brewer's yeast, the method is by no means

limited to this particular substance and can be as efficiently utilized with any substance containing protein or albuminous matter. By "modification" is meant the chemical reaction of ammonia on the albuminous constituents, which prevents coagulation and keeps them in solution.

Yeasts grown by fermentation are generally contaminated with substances of the extract fermented that may give a disagreeable taste to the yeast. This contaminating substance can be dissolved chemically or removed mechanically. Yeast resulting from the fermentation of malt or other brewing extracts which have been hopped during the brewing operation is contaminated with hop resin. The resins are preferably eliminated by the addition of alkalis or mechanically by forcing the yeast through a suitable filtering surface which will retain the resins.

The yeast treated as above is digested with a solution of ammonia (ammonium hydrate), preferably under pressure and while subjected to heat; or in lieu of pressure and heat, steam may be used. The pressure and heat help to weaken the cellular structure of the yeast and facilitate the action of the ammonia in solution on the contents of the cells, which are protein or albuminous matter. The cellulose matter of the yeast precipitates rapidly in the solution and the liquid may be drawn off.

The treatment of the yeast with ammonia under pressure and with heat must be to the exclusion of oxidizing agents. The excess of ammonia is removed by reduction of pressure in the digester or

in a special vacuum evaporator. The resulting extract is a protein or albuminous substance and is available in a solution form, particularly for enriching beverages normally lacking in protein. It may be used as a food per se, unadulterated, or adulterated, if desired, with any suitable substance to render it more attractive or palatable.

Responding to a demand for a syrup low in fermentable sugars the Corn Products Company have put on the market a special corn syrup called "Body Syrup" which contains the largest amount of unfermentable extract that can be commercially produced. Based upon analyses made by several brewing stations, the composition of this new Body Syrup, compared to that of our regular corn syrup, is approximately as follows:

	Regular Corn Syrup Per cent	Special or Body Syrup Per cent
Moisture	20	21.5
Maltose (fermentable) Dextrose	32	21.5
Dextrine, etc. (unfermentable)	48	57.0
	100	100.0
Moisture free composition.		
Maltose (fermentable) Dextrose	40	27.4
Dextrine, etc. (unfermentable)	60	72.6
	100	100.0

The above amount of dextrose and maltose, or fermentable extract, was determined by chemical analyses and represents more than is actually fer-

mented by yeast at the low temperatures employed in the brewery fermenter and chip cask, in which a part of the fermentable sugar remains unfermented and furnishes extract or "sugar remainder" in the beer. An actual fermentation test made with body syrup by one of the brewing stations, at temperatures approximately corresponding to those generally used in the fermenter and chip cask, gave the following results:

	Fermented at 8° R. Per cent	Fermented at 2° R. Per cent
Original Gravity	6.00	6.00
Alcohol formed (By Wt.)	.53	.16
Extract remaining	4.98	5.59
Extract unfermented	83.00	93.17

The opinion is quite common that maltose or "malt sugar" is produced exclusively from malt. This is not the case, however, as the different starches, used in brewing, such as barley starch in malt, rice starch in brewers' rice and corn starch in grits, meal and flakes when acted upon by diastase during mashing, all change to the same products, first to dextrines, then to maltose. When this maltose reaches the fermenter, it is further acted upon by another enzyme contained in the yeast, called glucase or maltase, which changes it to dextrose, before it ferments.

In the converter or pressure inverting process used in the manufacture of corn syrup and brewing sugars the same changes take place, the starch being likewise changed first to dextrines, then to maltose and finally to dextrose, but this is in one

operation. It follows, therefore, that by interrupting this converter process at an early stage, a product is obtained containing proportionately large amounts of unfermentable dextrines, compared to the fermentable sugars, and a proportionately large amount of maltose, compared to dextrose.

The high amount of unfermentable extract in body syrup makes its net cost much less than that of malt, even less than that of starchy adjuncts. If, as indicated by the above fermentation test, about 90 per cent of the body syrup is unfermentable when added in the chip cask, it means that only 10 per cent of the extract ferments to alcohol and carbon dioxide. Therefore, using malt with a yield of 64 per cent, a wort made from same with a ratio of sugar to non-sugar of 100:35 (equal to a sugar degree of about 74 per cent) and fermented in the usual way with the average 10 per cent "Sugar Remainder" from the maltose and dextrose, will yield, out of this 64 lbs. extract contained in 100 lbs. malt, only 21.3 lbs. extract in the beer. On the other hand, according to above fermentation test, 100 lbs. of body syrup extract will yield about 90 per cent extract to the beer. Therefore, as $90 \div 21.3 = 4.23$, it follows that 100 lbs. of body syrup extract will leave about 4¼ times as much extract in the beer as 100 lbs. of malt; in other words, 1 lb. of body syrup extract will equal about 4¼ lbs. of malt in yield value.

The above relates to amounts of extract only, but as the extract from malt costs more than the extract from body syrup, the money value differ-

ence is still larger, as per the following figures: At average prices of corn syrup and malt during past years, the extract from malt costs about 1½ times as much as the extract from corn syrup. Therefore, if 1 lb. of body syrup extract equals 4.23 lbs. of malt extract in yield value, it means, since 4.23x 1.5=6.35, that 1 lb. of body syrup extract equals about 6⅓ lbs. of malt extract in money value.

Finally, let me mention a process patented by Fritz W. Just, Minneapolis, for the preparation of a product which is not fermented, does not contain malt, and is not brewed but merely compounded, and according to the patent specification would appear to resemble beer in some respects.

This product consists of water, common salt, brewing sugar, hops, sugar coloring material, a foam retainer, tartaric or equivalent acid, yeast, and carbonic acid gas. The essential stages in the manufacture are as follows: Making a mixture of common salt and water, adding brewing sugar until the liquid has a specific gravity of about 1.0232, adding hops, and a sugar coloring material, boiling the mixture, adding a foam retainer, removing the spent hops, cooling the liquid to a low temperature, adding tartaric or equivalent acid, running the liquid into separate tanks, adding yeast to the liquid contained in one tank, mixing the liquid in the two tanks, and carbonating the same.

Lactic Acid Cereal Beverages. These beverages properly form a class by themselves and the methods of manufacture depend upon the employment of

natural fermentation lactic acid. They possess certain advantages which cannot be attained in any other way, inasmuch as the natural fermentation lactic acid has the property of supplying to the beverage certain characteristics, such as a snappiness capable of imparting to the palate a sensation which has the semblance to that produced by the presence of alcohol. Patents for the use of lactic acid are controlled by the Wahl-Henius Research Laboratory from which license for the use of the same must be obtained. Beverages of the lactic acid type may be manufactured either with malt or as maltless products. C. A. N.

FRUIT JUICES.

The unfermented fruit juice industry in America is growing very rapidly in the last few years. There are fruit juices on the market with very pleasing taste and aroma, and the demand is so rapidly increasing that the commercial success of this industry is very promising. A brewery with bottling outfit, located in fruit growing districts, can be very advantageously utilized for the manufacture of fruit juices.

Grape Juice.

The general method of the manufacture of unfermented grape juice is as follows: The grapes are crushed and run directly into steam jacketed kettles provided with mixing apparatus, which keep the crushed grapes continually stirred, while they are

heated to a temperature of about 140° F. The juice is drained from the crushed grapes and the pomace is pressed in a hydraulic press. The drained juice is mixed in kettles, heated to about 160° F. and skimmed; it is then run through a pasteurizer maintained at a temperature of about 180° F. From the pasteurizer the juice runs into sterile barrels or into five to ten-gallon carboys and is stored for about six months to allow the precipitation and settling of the precipitated matter. The clear juice is then siphoned off, filtered, bottled and pasteurized.

The bottled and pasteurized grape juice should be wholesome and palatable and free of sediment. A great many varieties of grapes do not possess a suitable composition for the manufacture of grape juice according to the method outlined above. Some of the grape varieties, for instance, are very rich in sugar and deficient in acid. The grape juice produced from them is insipid and unpalatable, notwithstanding that the grape with high sugar content is generally highly flavored. On the other hand there are other types which contain an excessive amount of acid and insufficient flavor to be suitable for grape juice, especially when sweetened with additional sugar.

A modification of the above-mentioned method was recommended by the Enology Laboratory of the University of California,* and as a result of their experiments with the utilization of California

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* These experiments were published by W. V. Cruess and E. J. Hintze in the Journal of Industrial and Engineering Chemistry, Vol. 6, No. 4, April, 1914.

grapes for the manufacture of unfermented grape juice, they proposed a judicious blending of different grapes to obtain a desirable composition. Grapes of high sugar content should be blended with grapes of high acid content. To obtain a bright juice they used different clarifying materials, such as casein, tannin, gelatin, albumen, isinglass, etc., with good results. Previous to the treatment for clarification the juice is allowed to stand for 24 to 48 hours to deposit all suspended matters. To prevent fermentation during this settling process, or as it is called "defecation," the juice is kept either at low temperature or treated with sulphurous acid. The following is the outline of the modified method:

1. Use a mixture of ripe grapes to give flavor with grapes of high acid, to remedy the lack of acid in the ripe grapes.

2. Add 8 to 12 ounces of potassium meta-bisulphite per ton of grapes at the crusher to prevent fermentation during defecation.

3. Allow the juice to defecate 24 to 48 hours and rack from sediment.

4. Add to each 100 gallons of juice 4 to 6 ounces of casein dissolved in sodium carbonate or ammonium hydroxide.

5. Add a small amount of tartaric acid to increase the rate of separation of the cream of tartar.

6. Heat the juice to 165° F. and store in 50-gallon barrels until most of the cream of tartar has separated.

7. Rack from the sediment and filter if necessary.

8. Add a small amount of citric acid to prevent further separation of cream of tartar, and bottle.

9. Pasteurize in bottle at 160° F.

This process is practical only when there is a possibility to find suitable grapes and there is considerable difficulty experienced in obtaining a uniform product.

An improvement in the manufacture of grape juice is in a process worked out and patented by A. Fonyo. According to this process the grape juice is subjected to lactic fermentation, whereby the high sugar content of a sweet grape juice is reduced, a part of the grape sugar being changed by the lactic bacteria into lactic acid and at the same time the acid content is increased. The acidity can be augmented at will and any desired proportion of the sugar and acid content can be obtained. The albuminous substances of the grapes are changed by some proteolytic action so that the precipitation of proteins in the bottled juice after pasteurization is prevented and the juice keeps clear for a very long time.

Apple Juice.

The extraction of apple juice from the fruit is similar to that of grape juice. The apples are first ground and then pressed in a hydraulic press, the difficulty is in obtaining a clear apple juice and in keeping the flavor during the pasteurization.

To remove the suspended matters of the pressed juice, which consists largely of albuminous sub-

stances, starch, and sometimes yeast cells, the juice is passed through a centrifugal separator and then filtered through paper pulp. If the juice cannot be readily filtered, an addition of clarifying materials such as used for grape juice may be necessary.

The pasteurization temperature should be as low as possible. According to H. C. Gore of the Fruit Utilization Laboratory of the United States Department of Agriculture, the bottled apple juice kept for one hour at 149° F. (65° C) gives good results and the heating of one half hour at 158° F. (70° C) is also a satisfactory process. It can be pasteurized as long as one hour at 158° F. without any marked deterioration of the product. It was also observed that carbonated apple juice retains its flavor during pasteurization more than the uncarbonated.

For the general method of preparations and extraction of juices from fruits other than apple and grape the reader is referred to Bulletin No. 241 issued by the United States Department of Agriculture and entitled "Studies on Fruit Juices," of which the following is an excerpt:

Grinding. If to be cold pressed, it is usually necessary to crush the fruit to facilitate the outflow of juice. Exceptions are the citrous fruits, which should be pressed after cutting in two, and pineapples, which may be pressed whole. Crushing is probably best effected by passing the fruits through an apple grater. The moving part of this machine, which is operated by power, consists of a rapidly rotating iron cylinder carrying short knives.

Heating. To increase the juice yield, intensify the color, or impart the desired flavor to the juice, the fruit may be heated before pressing, in which case crushing may be omitted. Juices of the small fruits are successfully prepared with or without previous heating. Pineapples, peaches, and the citrous fruits should be cold pressed.

Heating is conveniently conducted in a steam-jacketed kettle made of copper with tin lining or in one of aluminum, which should be fitted with a gate valve at the bottom for discharging the juice. To avoid scorching while heating, it is necessary to stir the fruit continuously.

Pressing. The system of racks and cloths extensively employed in this country in the manufacture of grape juice and cider is probably also best for preparing the juices of other fruits. The fruit or fruit pulp is built up in the following manner, in the form of square masses called "cheeses" in heavy press cloths separated by racks. A square rack is placed on the press floor. On this is laid a square form, over which is spread the press cloth arranged diagonally, the corners lying on the sides of the form. The cloth is large enough to permit a depression to be made in the center and still inclose the pulp completely when the corners are folded over. In the depression is placed the ground fruit, which takes the shape of the interior of the form, thus making a square cake or "cheese." The corners of the cloth are folded over and, if necessary, pinned

together. The form is then lifted off and another rack placed upon the cloth inclosing the "cheese." If desired another press cake may now be formed upon this rack, in which way a series of press cakes is built up until the entire space between the press floor and the head of the press is filled.

Racks of hard maple are best, as this wood is very strong and quite flavorless. Extra heavy racks are required in pressing citrous fruits and pineapples. The press cloths should be of the extra-heavy quality, sold by manufacturers of cider and vinegar makers' supplies.

The rack-and-cloth method has the merit of affording an excellent opportunity for the drainage of the mass of fruit while under pressure. An additional advantage is the ease with which the press, racks, and cloths may be kept clean. After pressing it is usually necessary only to wash off the press bed and racks with a hose. When the pomace has been shaken out, the cloths are cleaned by hosing off and by an occasional washing. Racks and cloths must be kept dry when not in use. When operating continuously, racks and cloths are apt to become heavily charged with yeasts, which infect the juices passing through and cause fermentation to occur very rapidly, in extreme cases even while pressing. This may be avoided by systematic daily cleansing of racks, cloths, and press.

The hydraulic type of press, operated by power, is very satisfactory. A steady but relatively light pressure is especially desirable in pressing the juice

from the viscous masses formed by the ground pulp of peaches and some of the small fruits.

Removal of Sediment From Fruit Juices.

Newly expressed fruit juices are invariably turbid because of the suspended substances present. A convenient way for removing the greater part of the sediment consists in passing the juice through a milk separator, which causes a large portion of the sediment to adhere closely to the walls of the bowl. By filtering through paper pulp a perfectly clear juice may usually be obtained. Infusorial earth* is recommended by filter press manufacturers as an aid in the filtration of liquids which contain slime, and the experiments on fruit juices here considered indicate that this substance may be generally used in their filtration. The addition of 2 per cent or less of infusorial earth to a fruit juice will in many cases produce a perfectly clear filtrate, as the infusorial earth prevents the stopping up of the pores of the filter by the slimy suspended substances of the juice.

Sterilization of Fruit Juices. Containers of glass, porcelain, or tinned iron (tin cans) in which fruit juices may be sealed and sterilized are availa-

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* Infusorial earth, also called diatomaceous earth, or kieselguhr, consists of nearly pure silica built up of the skeletons of microscopic sea animals called diatoms. When crushed and bolted it therefore exposes an enormous surface to liquids with which it is mixed. It possesses the property of opening up the slime which collects on the filter cloths, which otherwise would choke and render filtration impossible. Infusorial earth possesses this property to an extent not possessed by any other known substance. At the same time it is so inert that neutral or acid substances can be filtered through it practically without contamination. It is extensively mined in the United States and may be had finely bolted, ready for use in filtering, in carload lots at less than 2 cents a pound.

ble. The juice may also be poured while very hot into sterilized wooden casks, which are then sealed. Vessels of glass possess an obvious advantage in that a view of the contents may be had at any time without being opened. A. F.

Other Non-Alcoholic Carbonated Beverages.

Soda Water. Originally the beverage known as soda water was prepared by the action of an acid on sodium bicarbonate in solution and corresponded to what is now obtained by dissolving Seidlitz powders in water. Later it was found that water charged with carbon dioxide was not only more practicable commercially but also more acceptable to the palate, and this product was substituted for true soda water, without change of name.

As dispensed by the pharmacist and confectioner in the United States, soda water consists of a syrup variously flavored, mixed at the "fountain" with carbonated water. The syrup is first placed in the glass, then the carbonated water is drawn into it in a large stream and finally more added in a fine stream to mix and froth the liquid. Ice cream or liquid "cream" is used with certain flavors, eggs and milk in "egg chocolate," "egg shake," and other nutritious mixtures, a solution of calcium acid phosphate in "orange phosphate" and other phosphates; in fact there appears to be no end to the preparation and combinations introduced by ingenious venders to quench the thirst, gratify the palate, and furnish nourishment in an easily digestible form.

Carbonated Water, the basis of all effervescent drinks, is prepared by charging ordinary water with carbon dioxide in a steel drum, known as the fountain. Formerly the gas was generated on the premises by the action of mineral acid on marble, but now it is obtained in liquid form in steel cylinders from mineral springs and the fermentation industries, where it formerly went to waste.

The process of carbonating consists in allowing the gas to discharge into the water, rocking the fountain continually to aid absorption. A gauge indicates the pressure in the fountain, which should be about 170 pounds per square inch for soda water and somewhat less for ginger ale and root beer. The steel drum or fountain proper is kept in the cellar or other convenient place, and the carbonated water is piped to the so-called fountain where the drinks are served, or, in the case of bottled beverages, to the machine for filling the bottles.

Needless to say both the water and the gas should be free from contamination, and the introduction of metallic salts from the lead pipes and other sources should be guarded against.

Soda Water Syrups. Sugar and flavors are added to carbonated beverages in the form of syrups. At the soda fountain these are drawn into the glass from small reservoirs or poured from bottles, while in the bottling works measured quantities both of syrup and carbonated water are introduced into each bottle by an automatic machine.

Two classes of these preparations are on the mar-

ket, one for use in soda fountains, and one for "family trade," intended as a basis for sweetened drinks to be diluted with water and sugar. Some are made exclusively from pure fruit pulp and sugar, sterilized by heating and put up in tightly sealed bottles, while others of the cheaper variety are more apt to be entirely artificial both in color and in flavor, deriving the latter principally from the wide variety of artificial fruit essences now available, commercial glucose being a frequent ingredient. The same classes of coal-tar dyes and antiseptics are found in these preparations as in the other fruit products. Citric or tartaric acid is frequently added to genuine fruit syrups to bring out the flavor and to imitation fruit syrups to better stimulate the characters of the genuine product.

Fruit syrups are prepared either by the manufacturer of soda water supplies or else by the pharmacist or confectioner who serves the beverages. More commonly the manufacturer supplies the fruit juice or fruit pulp in bottles or jars, spoilage being avoided either by sterilization or the use of sodium benzoate. The vender mixes the juice or pulp with sugar syrup as needed. Orange, lemon, and lime syrups are commonly made from the oils rather than from the fresh fruit, the necessary acidity being supplied by citric acid. This acid as well as tartaric acid is also used in strawberry, raspberry and other true fruit syrups to bring out the flavor.

Imitation fruit syrups flavored with mixtures of ethers are frequently substituted for genuine fruit

syrups at soda fountains and quite universally in the preparation of cheap bottled soda water. Aside from the deception to the consumer these mixtures are highly objectionable because of their nauseating and unwholesome properties.

Various syrups not belonging under the head of fruit syrups are drawn from fountains and used in bottled beverages. Among these are vanilla, coffee, chocolate, "really cocoa," ginger, sarsaparilla, and mixtures sold under distinctive names.

Sodas. Some of these are high-grade articles of national or even international reputation, so prepared as to keep indefinitely, while others are cheap preparations of local manufacture sold for immediate consumption in pleasure resorts.

Ginger ale, by far the best known bottled carbonated beverage, is made from ginger (or ginger extract) with the addition of lemon juice (or lemon oil and citric acid) and carbonated water. Capsicum extract, known in solid form as capsicin, is frequently substituted in part for the ginger because of its greater pungency.

Root beer was formerly brewed from a sweetened infusion of various roots and herbs, the gas being formed by a true fermentation process. A similar beverage is now made in the household, using so-called "root beer extract," but the commercial product is commonly charged, like soda water, with carbon dioxide gas.

Birch beer, formerly made by fermentation, is

now merely soda water flavored with oil of birch or synthetic methyl salicylate.

Sarsaparilla, so-called, is flavored with a mixture of oil of birch, natural or synthetic, and oil of sassafras. The dark color is due to caramel or other artificial colors.

Lemon soda and orange soda are flavored respectively with terpeneless lemon and orange extract, the acidity being contributed by citric acid. Orangeade belongs in the same class. So-called blood-orange soda is probably never made from blood oranges, the color being artificial.

Vanilla soda is more correctly vanillin soda or vanillin and coumarin soda. The term cream soda applied to this colorless beverage is equally misleading.

Strawberry soda, raspberry soda and other bottled beverages purporting to be made from fruits are commonly imitations flavored with ethers and colored with coal-tar dyes. So-called cherry soda is flavored with an extract of cherry bark or benzaldehyde.

Evaporation of Fruit.

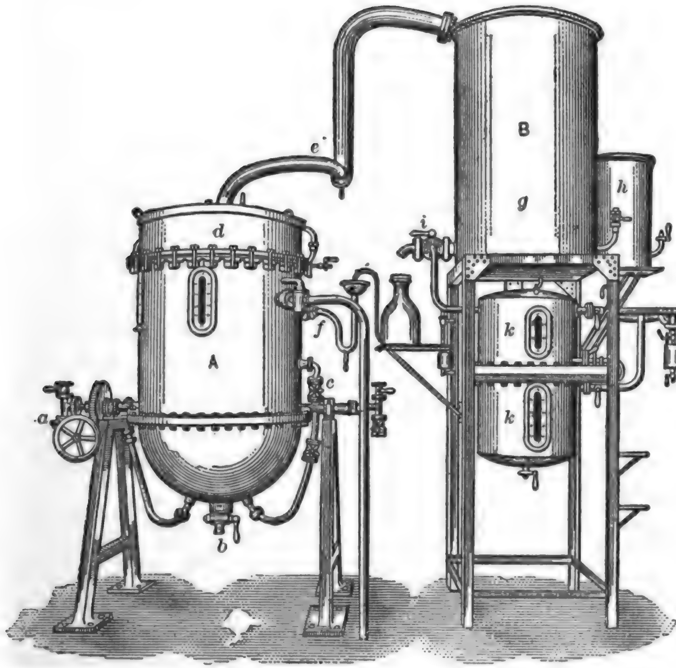
It has already been mentioned in the introduction, that the evaporation or dessication of food is a feasible and profitable undertaking for a malting plant because it enables the utilization of kilns which can hardly be used for any other purpose except possibly the drying of salvage from grain elevators. At any rate it is a field which the maltster

would do well to investigate, and his attention is therefore called to the work by Brannt on Vinegar which contains a chapter of a practical nature dealing with the subject and from which some of the following has been taken:

The usual equipment now extensively employed in the United States and which has superseded other drying devices is the so-called *kiln evaporator*, described by H. T. Gould in United States Department of Agriculture, Farmers' Bulletin, No. 291, which can be obtained for the asking from the government printing office at Washington, D. C. The above-mentioned book by Brannt also treats with the evaporation of vegetables, such as tomatoes, potatoes, corn, peas and beans, asparagus, beets, carrots, lettuce and in fact practically every vegetable of commercial importance, all of which lend themselves to this treatment if the proper conditions as regards temperature and air supplies are carefully observed.

In general evaporation is one of the most important methods employed for preserving fruits for any length of time. The reason for this can be readily given: The process does not require great technical skill; it excels in cheapness because neither vessels, sugar or other auxiliaries are required; the product possesses excellent keeping qualities, retains its natural flavor, and by many is considered healthier and more agreeable than fruit preserved by any other method. While much fruit is still dried in the sun, and large quantities of it are mar-

keted, the superiority of evaporated fruit has caused a large demand for it, and aside from the consumption in this country, large amounts are shipped abroad.



Vacuum still for fruit.*

A. THE COMPLETE STILL.
- (*a*) Stirring mechanism.
- (*b*) Cock for emptying.
- (*c*) Direct and indirect steam regulation.
- (*d*) Condenser cover.
- (*e*) Tube for carrying vapors.
- (*f*) Distillate return.

B. THE CONDENSER.
- (*g*) Main condenser.
- (*h*) Supplementary condenser.
- (*i*) Return tube with Florence flask.
- (*k*) Double receiver connected with the pump.

*Drawing taken from E. Walter, "Essence Industry."

The object to be attained is not only to make the fruit keep, but also to retain the properties for which it is valued. This can only be reached by withdrawing the content of water, and at the same time converting a portion of the starch into sugar in as short a time as possible without boiling the fruit. The latter would injure the taste of the fruit, and slow drying gives a flavor calling to mind, decay. The more quickly the watery portions are removed from thoroughly ripe fruit, the richer and more durable its taste will be; and the more completely the oxygen of the air is excluded during this process, the more perfectly will it retain its color. Rapidity of the drying process sometimes increases the content of sugar by 25 per cent, and this increase is in an exact proportion to the quicker or slower evaporation of the content of water, always provided, however, the fruit does not suffer injury from the heat.

No definite rules can be given regarding the temperature to be maintained in the kiln, this being largely a matter of experience. Some operators consider 150 degrees F. a suitable temperature when the fruit is first put into the drying compartment, dropping to about 125 degrees F. as the drying process nears completion.

The fruit, while drying in the kiln, has to be occasionally turned to prevent it from burning and from sticking to the floor. For the first five or six hours it is generally turned every two hours or so, and more frequently as it becomes drier, until per-

haps it may require turning every half hour when nearly dry.

When drying in the tower evaporator the trays or racks must not be too heavily loaded with fruit. Stone fruit not freed from the stones is placed close together with the stem ends upwards, but only in one layer. Plums after evaporating are generally brought into a bath of sugar water to give them a lustrous and uniformly dark appearance. For this purpose brown sugar is dissolved in an equal quantity of hot water, and the prunes in a wire basket are submerged in the bath for half an hour. They are then spread out upon hurdles and packed when perfectly dry. Quartered or halved stoned fruit, as well as sliced apples, are placed close together, edge upward, until the bottom of the tray is covered. Sliced pears are arranged in a similar manner. Of berries, several layers an inch deep may be made, but they must be covered with tissue paper. Grapes are but seldom converted into raisins in the evaporating apparatus, because the process would require 40 hours, it being impossible to use a temperature exceeding 167 degrees F. Hence it is considered more advantageous to dry grapes in the sun. The well-known Malaga raisins are obtained by allowing the bunches of grapes to dry in the air. They are dipped for an instant in boiling water to sterilize them and then dried on straw in the sun. When the grapes have shrunk to a third or half of their original volume, the best are packed in the original bunches, but the inferior raisins are picked

from the stalks before packing. The richer the grapes are in sugar, the less drying they need. In Spain the bunches are dipped into a boiling lye of wood ashes on which a little oil is floating. They are dipped and removed as quickly as possible, and the trace of oil that adheres to them gives a characteristic luster.

DE-HYDRATION.

The Concentration of Fruit Juices Into Syrup and Jelly.—Vegetable Drying.

By Paul Hassack, Weehawken, N. J.

More than ever before in the history of the world a decided liking for carbonated sweet beverages, still more so a pronounced appreciation and preference of unfermented sweet fruit juices over fermented beverages, is in undeniable evidence with a conspicuous majority of the people in the United States as well as many other countries.

Whether this occurrence is of doctrinary origin or instinctively in its initiative in the direction "back to mother nature" or both together, or a consequence of a variety of other causes is immaterial in view of the fact which we all know exists.

Nature indeed furnishes the easily extractable aromatic and pleasant tasting and also highly nutritious fruit juices in many instances ready made; nature, however, does not preserve them for us in the same form, for, with the fruit there is the natural agent, the yeast simultaneously furnished, a hint perhaps indicating the best and most beneficial natural method of preservation of God's gifts.

So as to preserve the fruit or the juice obtained from the fruit in its original sweet form we are compelled to either destroy or make inactive or separate the natural conserving element, the yeast. The elementary agent, however, is of a very resisting nature and its elimination is connected with certain difficulties and precautions by preventing exposure of sterile fruit juices to the air.

The principal methods of preserving fruit juices in the original sweet state are:

Exposure to high temperature (sterilization) thereby destroying or at least incapacitating the enzymatic and respiratory energy of the yeast cell.

Exposure to low temperature (cold storage) which in its effect is however only restrictive for limited periods of time.

Preservation by Chemical Antiseptics, a method when applied in small doses not harmful to the human system, is ineffective or but temporarily restrictive, and when applied in large and efficient quantities to destroy the life of the cell, renders the so treated fruit juice unfit for human consumption.

The perhaps oldest and safest method of juice preservation is the concentration or, more correctly expressed, the condensation of fruit juices into syrup or its pectous form, the jelly.

This method is practiced in almost any household and is, and has for long been utilized commercially, by boiling down the juice over direct fire in open

kettles in specially constructed steam evaporators or double-jacketed pans heated by steam.

In this process the juice is condensed to the density of syrup and is simultaneously freed of all impurities such as yeast, cellular tissues, flocculent albuminous matter, etc., which are the cause of the turbid appearance of freshly pressed fruit juices.

During the boiling process these impurities are thrown to the surface and then removed by skimming, a process called defecation. As a matter of fact it will be noticed that fruit juices, when exposed to a temperature already as low as 140-150° F. in the sterilization process, but still more pronounced when exposed to higher degrees of heat as boiling, lose considerably in the fragrancy so eminently valued and characteristic of fresh fruit and its juice.

All fruit juices concentrated by direct contact with overheated surfaces in the process assume an unpleasant by-taste, generally characterized as "cooked taste and flavor."

The elimination of this disadvantage has been under study for a considerable period and two processes have been found within the past few years, which are commercially valuable, economical and rendering perfect products with the character of the original fresh fruit fully preserved.

1) Concentration by freezing, 2) concentration under vacuum at comparative low degrees of temperature.

In the freezing process, which is fully described

in the March issue of the Vinegar Bulletin, the fresh fruit juice as it comes from the press is placed in tin-lined ice cans and frozen in the brine tanks at a temperature between 10-20° F.

The frozen juice is dumped from the cans, the ice passed through a power crusher and broken up into pieces of walnut size.

The crushed fruit ice dropped into a standard sugar centrifugal machine, will under the action of the centrifugal force, separate the syrupy part from the water ice similar to the separation of the molasses from the sugar crystals.

The syrup obtained is not as yet of the desirable density and is once more placed in cans, re-frozen, crushed and again centrifugalized.

Syrup density warranting lasting products is usually attained in two freezing operations.

The fruit syrup is then filtered by means of a filter press under addition of a certain percentage of infusorial earth to perfect brilliancy, and represents a valuable product for table, soda fountain or dessert use. The product can be kept in cold storage from one season to the other and can be shipped in bottles and barrels and used in dilution with water as an all-year-round sweet home drink, same as sweet fruit juices during the pressing season.

Fruit syrups can be profitably shipped for much longer distances to remote markets than the bulky fresh juice, inasmuch as one gallon of the concentrate represents about 5 gallons of fresh juice.

Concentration under vacuum is, as far as simplic-

ity of process is concerned, as well as with a view to palatively blameless standard products of well-preserving qualities, even preferable to freezing.

The best method under which operation is preferably conducted consists in at first clarifying the raw juice right from the press by means of a super-centrifugal separator, revolving at a speed of 40-50,000 RPM, by which all impurities held in suspension in the juice are deposited in the bowl of the machine, while the clear juice discharges through the screw outlets on top of the machine and is conducted to the vacuum condenser. In place of a high speed separator, clarification can be attained by filter press filtration and infusorial earth as above described.

The basic feature of evaporating or de-hydrating under vacuum is founded upon the practical application of the physical law, according to which the boiling point of water under a vacuum of 29 inches lies at 77° F. instead of at 212° under normal atmospheric pressure.

This enables us in the evaporation process of fruit juices under vacuum, to attain much higher drying efficiency under low temperature of 110° F., constantly removing the vapors formed in process, than is possible at 212° F. under atmospheric pressure in open pans or evaporators.

Exposure to high heat and atmospheric air simultaneously effectuates certain oxidation or caramelization and consequently a change of the original composition of the fruit juice which in turn finds

expression in the above-mentioned unpleasant by-taste of juices sterilized or evaporated under the application of high temperature.

Under vacuum, these changes cannot occur, and in consequence vacuum-treated products retain absolutely the character of the fresh fruit in regard to taste and peculiar fragrancy.

In addition to this the vacuum process is the most economical method from the commercial standpoint as to steam, respectively fuel, used.

Concentration of fruit juices as well as de-hydration of food products is a matter of predominating consideration, more so at this very moment than ever before in the history of our food supply.

The saving in storing, packing, shipping, distributing is so striking in proportion to the low cost of process, that the advantage of general adoption will necessarily follow as a matter of compulsion, not only relative to fruit juices but also in the preservation of meat and fish products, last but not least in vegetable and fruit drying, where the vacuum method is designed to supersede present methods of preserving food products in tin or glass containers.

Modern vacuum apparatus in the form of condensers, rotary, chamber or drum dryers are built within the widest range of commercial capacity and efficiency, and never too loud can the practical and general application of vacuum drying methods be advocated to the industries and should even under present emergencies not only find the moral, but also

financial support of our federal authorities, to the widest extent.

The writer, a strong believer in deeds, not in mere words, is prepared to take up any de-hydrating problems of fruit, vegetable, food or waste products by way of correspondence or personal interview, and to carry out practical experimental tests with a view of devising the best methods.

It is hardly necessary to point out that the more or less neglected field of de-hydration of food products offers strong opportunities and easy competition with products packed by present generally applied methods.

IV. The Yeast Industry and Its Products.

By Aladar Fonyo, Ch. E.

THE manufacture of compressed yeast as a branch of the fermentation industry is so closely related to brewing that the master brewer, with his knowledge of the theory and practice of fermentation, may thoroughly familiarize himself with it in a comparatively short time and with the greatest ease. Both have many similar processes in manufacture, and the equipment of a brewery with the addition of a few machines, can also be utilized for the manufacture of yeast.

Two methods may be employed in yeast making. One is the old Vienna process, yielding yeast about 12 per cent of the weight of the raw material, the other is the so-called Aeration process, which gives a yield of 30 to 34 per cent.

As a by-product alcohol is obtained, which is used for industrial purposes, or turned into vinegar. The Vienna process yields a higher percentage of alcohol, than the Aeration process. The aim of the yeast maker, however, is to obtain the highest possible yield of yeast, and since with the Aeration process nearly three times as much yeast can be produced as with the former, it is now being adopted by all new plants. This process will be dealt with here exclusively in the following paragraphs:

The Compressed Yeast.

The topfermenting culture yeast developed in a solution of carbohydrates, nitrogenous and mineral

nutritive substances when separated from the liquid and pressed to a partially dry formidable paste, is called compressed yeast. It is used as leavening agent in the baking industry and in the homes.

The compressed yeast contains 70 to 75 per cent of water, and 25 to 30 per cent of dry substances. These latter consist of an average of 63 per cent of proteins, 32 per cent of non-nitrogenous matters such as cellular substances, fat and glycogen, and 5 per cent of mineral substances.

As the composition shows, a large amount of nitrogenous nutritive substances is required to build up the yeast cells. Therefore, in the selection of raw materials for the manufacture of compressed yeast, the nitrogen content must be carefully considered. Barley, rye, corn and malt sprouts are the principal raw materials out of which yeast is made.

Raw Materials.

Barley.—The barley used for the brewing purposes is well adapted for the manufacture of compressed yeast. The six-rowed, small size, light weight barley is preferable to the full grained, two-rowed barley. The former is rich in protein, generally over 12 per cent, while the latter's protein content, as a rule, is below 12 per cent.

The germinating capacity of the barley must be high. Grains incapable of germination do not produce enzymes.

As to the other chemical and physical properties the valuation of the barley used in the manu-

facture of compressed yeast is identical to that used in the brewing industry.

Rye.—Rye is very advantageously used in the manufacture of yeast. The small grained rye, just like barley, is the more suitable, because of the higher content of nitrogenous matters. The 1,000 kernel weight is generally in indirect proportion to the nitrogenous substances, therefore from the weight of the kernels the protein content of the rye may be estimated. This relation, however, is not always dependable.

According to Wiley the composition of the average American rye is as follows:

	Per cent
Moisture	10.50
Proteins	12.25
Ether Extract	1.50
Crude Fiber	2.10
Ash	1.90
Carbohydrates	71.75

Weight of 1,000 kernels=25 grams.

When purchasing rye it should be examined as to its odor, by which moldy kernels are detected. New rye should be stored for over one month, just like new barley, before it is used for malting, as the germinating capacity of fresh rye is low.

Corn.—Corn is very rich in starch, but much lower in protein content than either barley or rye. Consequently in yeast manufacture it should be used in smaller proportion, than in the manufacture of alcohol or in brewing.

The following is the chemical composition of the average corn grown in the United States, according to Wiley:

	Per cent
Moisture	10.75
Protein	10.00
Ether Extract	4.75
Fiber	1.75
Ash	1.50
Carbohydrates	71.75

Weight of 100 kernels=38 grams.

The maximum moisture of corn should not exceed 14 per cent. The odor should be pure and the kernels free of mold. The color of the point of the kernel should be white. Brown point is an indication of faulty kernels.

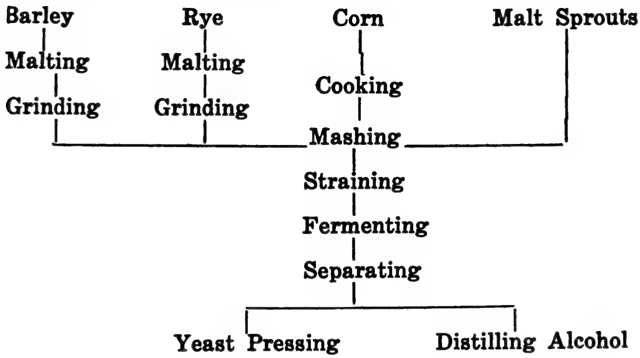
Malt Sprouts.—The following is their chemical composition:

	Per cent
Moisture	10.09
Nitrogenous Substances	24.18
Fat	2.10
Fiber	14.33
Ash	7.19
Carbohydrates	42.11

The high protein content, also the ash, which consists almost wholly of potassium phosphate makes the malt sprouts eminently suitable for yeast manufacture. Sprouts of pale malt should only be used, because the proteins, if kilned at a high temperature, will undergo an unfavorable change, and the dark color of the sprouts of the high kilned malt will darken the yeast, spoiling its appearance.

In using each of the above enumerated raw ma-

terials the operation of a yeast plant is outlined by the illustration below.



Preparation of Raw Materials.

Malting of Barley.—This operation is well known to the brewer, thus it would be superfluous to enter into its deeper discussion. It should be mentioned, however, that it is very important to produce a malt of highly diastatic and peptic strength, with the least loss of extractable substances.

Malting of Rye.—Rye of thin husk absorbs water very rapidly. Its steeping therefore takes up considerable less time than that of the barley, approximately 12 to 15 hours. For two hours the rye has to be kept under water, then washed by mixing it by means of compressed air. After washing, the rye again has to be kept under water for 7 to 9 hours, then 3 to 4 hours in the steeping tank but without water, after this it is ready for transfer to the malting floor for germination. The time of

steeping, however, changes with the variation of the water absorbing property of rye.

The germination of rye takes up 36 to 48 hours. During this process it should be turned frequently, as rye warms up quickly. The temperature should never exceed 25° C.

Generally a proportion of rye amounting to 10 to 15 per cent of the total raw materials is used for making yeast.

Preparation of Corn.—To dissolve the extractable substances the corn, either in whole kernels or coarsely ground, has to be cooked, preferably under pressure.

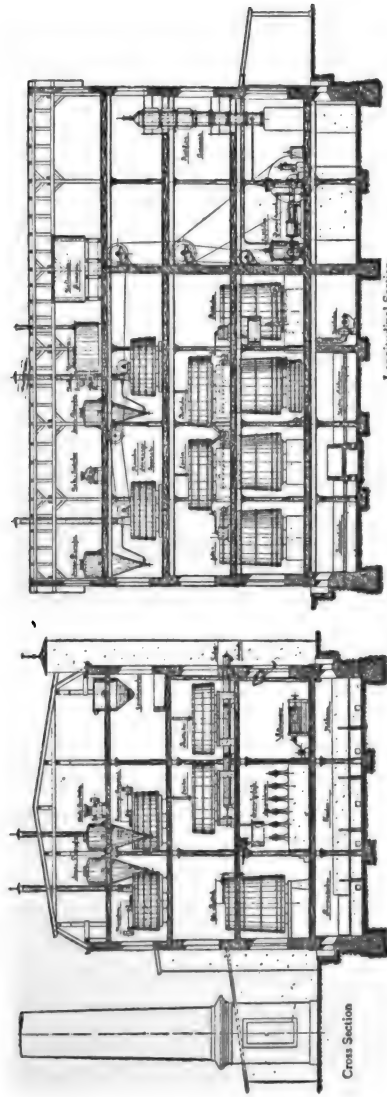
The "Henze pressure cooker" is widely used in distilleries and yeast plants. This apparatus has the shape of a cone with a steam inlet at the bottom. The inrushing steam carries the corn from the bottom upwards, forcing the corn on the upper part of the apparatus to fall down and also to come in direct contact with the inflowing steam, and to be lifted up again by it. This apparatus proved to be very efficient.

Corn products, such as corn grits or flakes, may be used instead of corn; they should be gelatinized by coöking or ground very finely so as to allow a large working surface for the diastase.

Grinding.

For the grinding of dried malt a regular brewers' malt-mill is suitable.

Wet, or so-called green, malt is used generally by



Sections through a Compressed Yeast Factory, Aeration Method. (Designed by Gebrüder Sachsenberg, Rosslau in Anhalt, Germany.)*

***Taken from Martin.**

the yeast manufacturer, as it has higher diastatic power and the straining is much easier and quicker.

Assuming the diastatic power of the green malt as 100, the following table illustrates the weakening of the diastatic strength by drying the malt at different temperatures (according to Kjehldal).

	Diastatic power of the dry substance
Green Malt	100
Malt dried at 50° C.	88.2
Malt dried at 60° C.	78.3
Malt dried at 70° C.	52.1

The green malt grinder consists principally of two corrugated steel rollers revolving in opposite directions. The malt is conveyed into the feed regulator, where it is uniformly distributed, and then sent to the rollers to be crushed. The rollers can be adjusted according to the size of the kernels. The kernels are crushed properly when pressed flat so that the endosperm breaks through the husks.

Proper care should be exercised in feeding the malt uniformly, because the rollers are so adjusted that they can crush only a certain amount of malt within a certain time. Should the malt be fed faster than demanded by the adjustment of the rollers, the kernels will be crushed into too small parts causing difficulties in straining the wort later.

The capacity of the grinder can be increased by setting the rollers at a greater distance apart. This should be done very carefully, however, for if the rollers are set too far apart, and permit the kernels to pass through the rollers uncrushed, a waste of material will result.

The rye is ground in the grinder of barley malt. The latter is crushed first, then the rye and dropped by the gravity or conveyed into the mash tank.

Mashing.

The process of mashing in manufacturing yeast, greatly differs from that employed in brewing. While the brewers' aim is to produce a wort containing not only certain desirable proteins, but also a quantity of unfermentable sugars, the yeast makers' object is to dissolve the greatest possible amount of protein, and to change all carbohydrates into fermentable sugar.

In brewing, the albumins, which tend to injure the stability of the beer, have to be eliminated. A large part of the albumins is precipitated during the process of boiling the wort with hops. In yeast making all dissolved proteins must be preserved, therefore the wort must not be brought up to such a high temperature, at which albumin would coagulate. Since the wort has to be sterilized at a low temperature, great attention must be paid in all operations to retard the development of foreign micro-organisms.

First of all the mashing water must be pure, technically free of infection, and not very alkaline. Alkaline water would neutralize part of the acidity of the mash, and the acids must be preserved in order to retard the development of bacteria. The alkalinity of the water may be reduced by adding sufficient sulphuric acid before mixing it with the grains. Sulphuric acid neutralizes the alkaline

salts of the water, the bicarbonate of calcium and magnesium and yields sulphate of calcium resp. magnesium, both of which remaining in solution in the wort serve as mineral yeast food in the course of fermentation.

The proportion of mashing water to grains in a yeast mash differs from that of the brewers' mash. Enough water should be used to make the concentration of the "first run wort" about 10 to 11 per cent Balling. In a heavier mash, the action of the enzymes is not as thorough, especially in the formation of maltose.

To dissolve the proteins of the grains, the mash is subjected to the action of the proteolytic enzymes of the malt. It is held at a temperature of about 52° C for 30 to 45 minutes. The peptonization during this short time will not be complete, but the time must not be extended, because at this low temperature the micro-organisms, especially the molds, which always enter into the mash with the malt, will neither be destroyed, nor their development entirely retarded. Peptonization will be completed at a later stage of the mashing, during the acidifying process with the aid of lactic bacteria.

The temperature of the mash is then raised from 52° C up to the saccharifying point. This must be much lower in the yeast mash than in the brewers' mash, because at a high temperature not only maltose but a large amount of unfermentable sugars are formed. The inverting temperature varies from 60° to 65° C according to the diastatic strength of the malt and according to the method

with which the acidifying of the mash is performed. The action of the diastase should be complete after 4 or 5 hours at saccharification temperature, and nearly all the carbohydrates in the solution should change to maltose.

After complete inversion the mash is subjected to lactic fermentation, commonly called, souring process, for the following reasons: The lactic acid and the lactic bacteria retard the development of micro-organisms injurious to culture yeast, and increase the activity of culture yeast. Lactic bacteria helps to decompose the higher proteins to a simpler form, which the yeast cells can readily assimilate. Lactic bacteria activate the proteolytic enzymes of the malt or may themselves develop enzymes, which, however, is not as yet positively proven. But it is an established fact that the action of lactic bacteria is decidedly beneficial to the quality and quantity of yeast.

There is always a considerable amount of lactic bacteria present in the malt, especially in the green malt. Most prominent amongst these are the so-called termophile bacteria, which develop more favorable at a high temperature.

Many plants depend entirely on these lactic bacteria to perform the acidification. In this instance the highest saccharification temperature is 62° C, at which the termophile lactic bacteria are not destroyed. The mash is then cooled to 57° C and is subjected to spontaneous lactic fermentation for 15 to 24 hours, during which time ample lactic acid is formed.

In other plants pure culture of lactic bacteria is prepared in a separate small mash, and then the main mash is inoculated with them. This method of acidification is more uniform and reliable. The temperature of inversion may be as high as 65° C at which degree the micro-organisms in the mash are either destroyed or lose so much of their vitality that when the mash is cooled to 57° C and inoculated with the pure culture of lactic bacteria, they are incapable of development, the latter only developing. After inoculation the mash is kept between 55° and 57° C for about 16 hours until the required quantity of lactic acid is produced, which should be 6° (the degree of acidity means the amount of cubic-centimeter normal alkali solution necessary to neutralize 100 cc mash).

At a lower acidifying temperature the lactic acid is more quickly formed. As an illustration let it be mentioned that 6° acidity can be produced in about 6 hours at a temperature of 50° C. Yet, it is not advisable to keep the temperature very low during the souring process, because the dissolution of the protein in the mash requires a higher degree of temperature and longer period. According to Kiby the plazm of lactic bacteria contains not only a lactic acid producing, but also a proteolytic enzyme. The optimum temperature for the proteolytic enzyme is higher than that for the acid forming enzyme; at low temperature, therefore, only the sugar decomposing enzymes produce lactic acid, and the proteolytic enzymes are almost in-

active. The most advisable temperature for the acidifying process, at which both kinds of enzymes are simultaneously active is 57° C, notwithstanding that at this degree their action is slower.

Preparation of Lactic Mash.

As intimated in the preceding chapter pure culture of lactic bacteria, with which to inoculate the inverted mash, is generally developed in a separate small mash. This latter is prepared in a small tank provided with heating and cooling coils and a mixing device. For material 75 per cent of barley malt and 25 per cent of rye malt is mixed with enough water to produce wort of a concentration of 20 per cent Balling. The mash is peptonized at 52° C, inverted at 65° C and sterilized by heating it up to 82° C. After keeping it at this degree for one hour the mash is cooled to 55° C, and transferred into sterilized vessels, where they are inoculated with pure culture of lactic bacteria. The vessels containing the inoculated mash have to be kept in a thermostat at a constant temperature of 55° C, where in 48 hours 1½ to 2 per cent of lactic acid and a large number of lactic bacteria will develop. Then the lactic mash is ready to be added to the main mash for the acidification.

About one gallon of the lactic mash should be kept for the inoculation of the next day's lactic mash. The same culture may be used for months without impairing its activity, but great care should be exercised to prevent any infection.

Mashing Operations.

The brewers' mash tun may be used for mashing, which must be provided with heating and cooling coils and a mixing device. One with a capacity of 150 bbls. is suitable for the mashing of 5000 lbs. of raw materials. The proportion of raw material may comprise 3500 lbs. of barley, 850 lbs. of rye and 650 lbs. of malt sprouts. If using corn or corn-products the proportion of malt sprouts should be increased. To the mashing of 5000 lbs. of material 4000 gallons of water is required.

The mashing water should be added into the tun first and heated up to 52° C, then the malt sprouts are added, next the barley-malt is crushed and added, and finally the rye malt. During the entire time, while the grain is being mixed in, the water in the tun has to be stirred constantly.

Having placed the said materials into the tun, the whole mash is heated up to 52° C, at which it should stand for 30 minutes. Then the corn either cooked or ground very fine is added and the temperature is raised up to the saccharifying point gradually in the following manner: First to 58° C, there to be left for 30 minutes, then up to 61° C, and kept at that for one hour, next up to 62° C, to stand there for another hour, and finally up to 65° C, where it should be kept for 3 or 4 hours.

(If spontaneous lactic fermentation is employed instead of lactic culture, the temperature must not be raised beyond 62° C, at which degree it should be kept for 4 or 5 hours).

After the inversion is completed the mash is cooled by means of the water circulating coils to 57° C, about 30 gallons of lactic mash is added and then the mash is stirred for 15 minutes in order to thoroughly distribute the lactic bacteria. The mash should be stirred once in every two hours for 5 or 10 minutes, and whenever the temperature sinks down to 55° C, it has to be heated up to 57° C again. Kept constantly between these two degrees the acidification is completed in 16 hours, and an acidity of 6° is obtained. Then the temperature is raised to 70° C, and kept there for 10 minutes in order to destroy the lactic bacteria.

If the mash tun cannot be spared for the entire process of saccharification and acidification for lack of equipment, a few fermenting tubs may be used in place of it. These are generally provided with coils for cooling and must be also fitted out with direct steam heating pipes, and a mixing apparatus. The mash is transferred into the tubs from the tun after all the materials have been mixed in the water, and both processes of saccharification and acidification completed there in exactly the same manner as described above.

Straining.

Upon completion of sterilization the mash is transferred into the strainer. The false bottom vat, well known to brewers, is used for separating the wort from the grains. This operation in yeast making is identical with that in brewing and here also

the same precautions must be taken to prevent the slow flow of the wort.

From the strainer the wort is carried into the fermenting vats through the cooler.

After the wort is run off, the grains are sparged with hot water. The temperature of water should be about 70° C, the same as the temperature of the mash was when sterilized. During the sparging process the grains should be stirred several times in order to assist in dissolving the extractive substances. The sparging must be continued until the extracts in the water fall below one-half of one per cent. With the sparging water the wort will be diluted to 4½ to 5 per cent Balling.

Fermentation.

The filtered wort is inoculated with the stock yeast and fermented under constant aeration. This latter serves to introduce oxygen into the wort to promote the respiration process and the reproduction of the yeast cells. The yield and quality of yeast depends upon the nutritive substances, concentration of wort, the temperature of the fermenting wort, and aeration.

The *nutritive substances* must be present in such form that they may be readily assimilated. Thus the carbohydrates have to be changed to maltose and the proteins should not have higher molecules than the albumose group.

The *concentration* of the wort must be below 6 per cent. At a higher concentration so much

alcohol will be produced that its strength will retard the growth of yeast. Also the proteins distributed in a thin wort will be more easily assimilated by the yeast cells.

In a dilute wort the yield of yeast is high, but the yield of alcohol is reduced. According to Kiby the action of the alcohol producing enzyme, zymase is retarded by the proteolytic enzyme, tryptase of the yeast. It seems that the zymase is protected against the tryptase by the sugar of the wort. (The brewers' yeast developed in a wort of low protein and high sugar content, contains more active zymase than the compressed yeast.) Dilution of the wort lessens the protection afforded to the zymase by the sugar, which naturally reduces its alcohol forming action, and promotes the action of the tryptase.

The *temperature* of the fermenting wort varies from 22½° to 30° C. The "pitching" temperature is generally 22½° C, which is raised gradually by the heat generated during fermentation, but should never be allowed to exceed 30° C.

The optimum temperature of the top fermenting yeast is higher than that of the bottom fermenting yeast. At low temperature the activity of the top fermenting yeast is reduced and the slow acting yeast has time to work up the higher proteins and to use it for the formation of new cells. The lowering of the fermenting temperature, therefore, would increase the yield of yeast. Nevertheless it is not advisable to have the fermenting temperature too low,

because the time of fermentation is prolonged, the wort is exposed to infection of wild yeast and bacteria for too long a time.

Aeration depends upon the concentration of the wort. The more dilute the wort is, the more air is required. At 5 per cent Balling concentration, about 35 cubic yards of air is to be pressed into the wort for each 100 lbs. of raw material per hour. Using 5000 lbs. of raw material, 17,500 cubic yards of air has to be introduced per hour.

Stock Yeast.

The wort is "pitched" with stock yeast to start fermentation. This stock yeast is prepared out of yeast propagated in a pure yeast culture apparatus or of a good quality compressed yeast produced by the Vienna process without aeration, by adding it to wort of a concentration of 10 per cent Balling and having it fermented in a small fermenting tub with little aeration at a temperature of 25° to 30° C for one day. Thus sufficient yeast is developed to inoculate with a larger quantity of wort, which is then fermented under normal aeration. The produced yeast is separated from the wort, pressed and ready for use as stock yeast in the following days.

The amount of stock yeast required to start fermentation depends upon the quality of the yeast, upon the materials used and upon the concentration of the wort. As a rule it is 5 to 6 per cent of the total weight of the raw materials used.

In some plants this large quantity of stock yeast

is reduced by employing a so-called "pre-fermentation" process. This is carried out in a smaller fermenting tub (about one-tenth the size of the main fermenter) into which first run wort of about 10 per cent Balling is transferred, and stock yeast about 2 per cent of the total weight of the raw material is added. Four to five hours' fermentation with aeration produces sufficient stock yeast to start with the fermentation of the rest of the wort in the main fermenting tub.

The so-called "first generation yeast," which is the yeast made out of the stock yeast, may also be used for stock yeast, but it is not advisable to use second or later generation yeast for this purpose, because the yeast easily degenerates through the enforced life functions due to the strong aeration.

The Process of Fermentation.

From the strainer the wort is run by gravity or pumped into the fermenting tub through the cooler, which may be open (Baudelot) or closed (double pipe) cooler. The fermenting tub in addition to the cooling pipe coils has to be provided with an aerating apparatus. This can be easily completed, since the breweries have air compressors.

The air from the air compressor enters into the air washer, which is an upright iron cylinder containing water to retain the impurities of the air. In cold weather this water is heated up to serve as an attemperator for the air. From the washer the air goes into the fermenting tub through a vertical

pipe and finally into the wort, finely disbursed through horizontal distributing pipes.

The stock yeast is added when the wort, cooled to 22½° C, reaches the horizontal airpipes above the bottom of the tub. To start the fermentation of the wort made out of 5000 lbs. of raw material, 250 to 300 lbs. of compressed stock yeast is necessary, and it should be dissolved in cold water before adding it to the wort. Then fermentation starts immediately and proceeds during the balance of the straining and sparging.

Upon the completion of sparging the concentration of the diluted wort is about 4½ per cent Balling.

On account of the dilution and also because part of the acids become neutralized by the alkalines in the water, the 6° acidity of the first run wort is reduced to around 2°. Sufficient sulphuric acid has to be added to bring up the acidity of the wort to 2½°, this being the correct degree, which does not hinder the growth of the cultured yeast, yet prevents the development of foreign micro-organisms, which enter into the wort through the air and water.

The acidity in the wort also prevents the flocking of the yeast, in which state the pressing of the yeast is rendered very difficult. If in a wort of 2½° acidity flocculent yeast develops, it is a sign of degeneration of the yeast, and the only way to remedy it, is to introduce new stock yeast.

As already mentioned, the temperature of the wort, when fermentation starts, should be 22½° C, the heat developed by the yeast will raise this up

to 30° C. At reaching this point the wort should be cooled, as a further raise of temperature would be detrimental. All the sugar ferments in 8 to 10 hours. Aeration, however, should be continued two to three hours longer, but with less air, and cooling the wort to 25° C. No alcohol develops during this course of aeration, the yeast cells only are reproducing. Too long aeration must be avoided, as the forced development of yeast weakens and injures its quality.

Separating.

The next step is to separate the yeast from the fermented wort. Some yeasts have the property of settling on the bottom of the fermenting tank, while others remain suspended in the wort for a considerable length of time. The separation of the former type is simple. When the yeast is settled on the bottom of the fermenting tub after the aeration has been discontinued, the clear wort is siphoned off.

It occurs sometimes, when the mashing process, especially the acidification, was not properly executed, that this settling type of yeast also remains suspended in the wort and it would take several hours to settle. During this time the yeast is exposed to infections. It is necessary, therefore, to separate the unsettled yeast in a mechanical way. In every modern yeast plant centrifugal yeast separators are in use for this purpose.

The separating outfit consists of a small iron tank placed upon an elevation, into which the wort con-

taining yeast is pumped from the fermenting tubs. The wort flowing in on the top passes through a sieve in order to retain grains, most probably malt sprouts, which may have gone through the mash strainer. By gravity it flows into a horizontal main pipe, from which it is carried through narrower pipes to the receptacles of the yeast separators.

These operate practically on the same principle as the cream separator. The centrifugal force separates the heavier yeast from the lighter liquid.

The correct speed of the yeast separator is 4500 revolutions of the bowl per minute. The wort and yeast should not be introduced into the bowl until this speed is attained; at the start the bowl should be filled with water. The separated yeast in a heavy liquid runs off at the lower spout, is cooled then by an open Baudelot cooler, and transferred to the pressing room.

The wort, which should be entirely free of yeast cells, runs off at the upper spout and is collected in a tank. It contains about 1.6 to 1.8 per cent of alcohol, which is distilled off, and may be used as industrial alcohol or for the manufacture of vinegar.

The capacity of a separator is about 650 gallons per hour. To separate wort made out of 5000 lbs. of raw material, five separators are required and the operation is performed in about three hours.

Pressing.

The liquid yeast separated from the wort has to be filtered in order to obtain a solid yeast. For

this purpose a filter press is used, which consists principally of several grooved plates with raised edges set in a horizontal series on a strong support. The plates are covered with filter cloths and when forced together each pair encloses a chamber. A hole generally in the center of the plate affords a channel, through which the liquid yeast is pumped into the press. The yeast remains in the chambers between the filter cloths and the liquid is pressed through the cloth and passes down the grooves of the plates through taps into a receptacle.

The yeast gradually fills up the chambers, the flow of liquid through the taps becomes gradually slower, and when the running off of the liquid practically ceases, the pressing operation is ended. The plates are taken apart and the compressed yeast from the chambers is collected.

Under normal conditions there is no difficulty in the pressing of yeast, except in the case of an improperly developed yeast, which may cause trouble in pressing.

The compressed yeast is cut into 1-lb. or ½-lb. pieces of a prismatic form for the bakers' use in a cutting and dividing machine or cut into small cakes for household use. A. F.

Yeast as a Source of Vegetable Protein.

The recent researches by Delbrueck, Frank, Caro, Haber, Hayduck, which were necessitated by the economic conditions caused by the war, have led these investigators to develop a process in which

the yeast cell is employed for the purpose of extracting the nitrogen from the air and accumulating within the organism large amounts of vegetable proteins. It has been found that yeast will multiply very rapidly in a mixture consisting of carbohydrates and mineral nitrates or nitrogen as contained in the atmosphere. As a result the yeast is capable of producing unlimited amounts of protein within a few hours. The final nitrogen content is considerably larger than is present in any of the grains.

In view of this it has even been suggested especially in Germany, where the question of foods is very important, to collect the refuse remaining from meals and to purify the same by boiling with water or similar treatment, and add the necessary amount of mineral nitrates and to use this as a culture medium for the propagation of yeast.

Fat From Yeast.

Besides investigating the manufacture of albumen from yeast cultivated in sugar solutions which contain mineral matter as yeast food, the question of the production of fat in a similar manner has been taken up by the Institute for the Fermentation Industries in Berlin. The yeast employed as a human food and as cattle feed contains, as a rule, up to 4 per cent of fat. It is a known fact, however, that the accumulation of fat in the yeast cells can be increased.

It was the aim of the Institute to find micro-organisms which are able to accumulate large quantities

of fat while using only a small amount of nutritive substances.

Professor Dr. Lindner, head of the biological department, succeeded in finding types of yeast which possess the desired properties. A dried yeast was obtained which had the following composition, in a water free condition:

Ash	8.08
Organic matter	91.90
Crude protein	31.40
Fat	17.06
Carbohydrates	43.44

It can scarcely be doubted that a still higher percentage of fat may be attained. There are already four such micro-organisms under investigation which promise very satisfactory results.

The quantities of yeast obtained from the raw materials are not as large as with the ordinary yeast used as feed, yet they are sufficiently great to warrant manufacture on a big scale. First of all, the new dried yeast will supplement the nutritive value of the yeast formerly manufactured. So far the fat producing yeast was only propagated in heavy films on the surface of liquids contained in shallow dishes. As soon as it will be possible to obtain the same yeast inside of liquids while aerating the latter, manufacture on a large scale can be undertaken.

The fat extracted from the dried yeast is of oily nature and furnishes a pure soap of good quality and pure odor. The fat is most likely not formed from albumin, but its production seems to be due to a

direct transformation of sugar, perhaps by way of glycogen, into fat.

A special department has been created in order to hasten the work on this subject, and the assistance of a prominent chemist has been secured who is going to investigate the matter from a purely scientific, chemical standpoint, while Dr. Voeltz is conducting experiments on the digestibility of yeast fat.

It is to be expected that the extremely interesting questions will be solved in the near future.

The Therapy of Yeast.

The yeast plant, Saccharomyces cerevisiae, has long been recommended for boils, and in recent medical literature we find it indicated in a number of diseases, so varied, in fact, that it has been treated with the usual apathy exhibited toward new drugs or new applications of old ones.

Dr. Julius Ullman, in a paper on the subject read before the Erie County Medical Society, May, 1902, and published in American Medicine (October, 1902), says:

The study of immunity has taught us that the natural resistance of the body is due to several causes: (1) The fixed and movable cells having an inherent property of secreting a substance, proteid in character, which acts as a protective to the organism; (2) Metchnikoff's phagocytic action of the polymorphous leukocytes acting by (a) chemiotaxix and (b) by secreting a substance germicidal in character; (3) the body is capable of producing antitoxines

under stimulation of certain proteid enzymes; (4) when the body has lost its resistance, the presence of a secondary agent may retard or inhibit the primary infection.

Brewers' yeast is not an ideal pharmaceutical preparation per se, and this is perhaps one of the chief reasons why it has not been recognized as it should be. Its frothy appearance and odor (unless quite fresh) make it repulsive; and in Europe it is never used in this form, but preferably in a form known as "Cerevisine." This represents in a concentrated form (which can be kept indefinitely) the ferments, nuclein, nucleinic acid and phagocytic activity which are essential for therapeutic effects.

Cerevisine (desiccated yeast cultures) destroys gonococci staphylococci and other pathogenic organisms.

The employment of yeast consequent upon the recognition of its value by a large number of practitioners is very general, and no one can well be ignorant of its value in the treatment of furunculosis and certain skin diseases. The principal obstacle in the way of this treatment becoming universal, has been the difficulty experienced in obtaining the yeast fresh and in preserving it from secondary changes, which take place with great rapidity.

Cerevisine is a pure culture of the spores of brewers' yeast, desiccated in vacuo at a low temperature so as to preserve its vitality. This dry yeast preparation is possessed of the same therapeutic activity as the best fresh yeast, besides being more concen-

trated and constant in its effects. It is prepared in the granulated form in order to facilitate its administration.

*Plastic Masses From Yeast.**

The beginning of the experiments made by the author in connection with E. Krause date back about three years and were not prompted by the war. Patents on the process have already been granted in Germany, and it is, therefore, possible to publish at least some general data in regard to the product and its process of manufacture.

A utilization of the waste of the yeast extract industry had been the original intention. Such yeast extracts are sold as substitutes for meat extract. In their manufacture the extremely fine cell walls of the yeast remain undissolved and this cellulose shows peculiar characteristic reactions, with numerous chemicals.

It was possible to produce from it, by the action of aldehydes, plastic masses which by high pressure and simultaneous heating could be formed into a hard, solid product, which we call Ernolith and which can serve as a substitute for Ebonite and under certain conditions for Galalith, Bakelite, Resinite, Celluloid, etc.

The next step consisted in trying to employ yeast itself for the same purpose, and the experiments led to various interesting discoveries. We learned to vary the product in regard to hardness and elas-

*From a Paper by A. Bluecher, "Chemiker Ztg."

ticity, at least within certain limits. The original black color could be changed; we succeeded in producing yellow, gray, brown, red, green and blue tints by incorporating mineral dyes into the mass. Several additional chemicals, besides the original substances, yeast and aldehyde (mainly formaldehyde) were gradually introduced into the process in order to obtain products with different physical or chemical properties.

For a long time we were hampered by the necessity of pressing the product of reaction immediately or at least within a very short time. This difficulty was overcome, however, and now the process of manufacture is divided into two distinct phases. The yeast is treated with formaldehyde with the addition of some other chemicals and fillers and the resulting mass is dried and ground. The durability of this powder is unlimited and in this form it is furnished to the manufacturers, who press it into the required shapes.

The forming of the raw Ernolith is done in heated hydraulic presses. The finest details of the mould can be obtained and the most exquisite reliefs reproduced with absolute sharpness. There is also scarcely any waste since the dry powder can be weighed out very accurately for each mould. Ernolith can also be worked mechanically after pressing, f. i. it can be sawed, filed, bored, turned, engraved, polished, etc. Its structure is a very dense one and it can be made either hard and brittle or softer and more elastic. It will not burn and chars with diffi-

culty only. The specific gravity of the pure material is 1.33 to 1.35.

For certain purposes it seems of considerable value that Ernolith will adhere tightly to metal parts with which it is pressed together. Metal wires, wire screens or other metal objects may thus be imbedded in Ernolith. It is also possible to incorporate vegetable and animal fibre or asbestos in the material.

A special company has been founded in Leipzig for the exploitation of the new invention.

V. Vinegar.

THE vinegar industry while of no great commercial importance is of interest because it is so intimately associated with the brewing and wine making industries. Beer as well as wine are products of fermentation, likewise vinegar. While the fermentation in beer and wine is of an alcoholic nature, induced by a micro-organism, the yeast, containing the active enzyme Zymase, which possesses the virtue of decomposing sugar into alcohol and carbonic acid gas, the fermentation yielding vinegar is an acetic fermentation and is induced by the organism "mycoderma aceti" existing in the "mother-of-vinegar."

The Bacterium Aceti of which many varieties exist is usually employed in pure culture, the method of preparing such pure cultures in general being similar to those employed in the preparation of pure yeast cultures. Unlike the yeast, however, the acetic acid bacteria do not act upon sugar directly, but only upon alcohol, which is usually obtained by the alcoholic fermentation of any suitable sugar containing materials such as fruit juices, or extracts of grains.

From the above it is evident that wines, beers, and all other more or less impure alcoholic solutions of moderate strength constitute suitable raw material for the production of vinegar. It must be remembered that, analogous to yeast, which will not grow in pure sugar solutions, the acetic acid bacteria

will not grow in a pure aqueous solution of alcohol but require as a condition of life, besides alcohol, the presence of nitrogenous matters and salts to serve as food.

In the United States, apple cider is most generally used as a raw material, while in England malt, or a mixture of malt with grain and sugar constitutes the chief material for vinegar production. Other materials which can be used are beer which has not been hopped, beet sugar solutions, diluted alcohol mixed with malt infusions, and occasionally glucose or molasses.

Where malt is employed in part this is done for the purpose of inverting the starch of the raw material employed in conjunction with it, the process of preparing the mash being in general very similar to that employed in brewing.

It is also customary in England to prepare a wort suitable for vinegar manufacture from raw grain such as rice or corn, without the addition of any malt, by what is known as the conversion process. According to this process the grain contained in a closed converter is treated with a dilute solution of sulphuric acid whereby the starch is hydrolized into sugar, the sugar solution being then freed from acid by means of calcium carbonate, and the liquor or wort separated from the precipitated calcium sulphate. The wort is now pitched with yeast and is aerated and kept at a temperature which will convert as much as possible of the sugar into alcohol. The strength of the vinegar obtained depends en-

tirely upon the success of this stage, because all of the saccharine matter (also dextrines) escaping the action of the yeast also remain unattacked by the acetic bacteria. The resulting liquor which should contain from 6 to 7 per cent of alcohol is inocculated with acetic bacteria and subjected to acetic fermentation.

The acetic ferment propagates rapidly in a liquid containing from 2 to 3 per cent of alcohol, nitrogenous matter, and phosphate of potassium, calcium, or ammonium, if the temperature is kept between 20° and 35° C. A thick film, or skin, forms on the surface of the liquid, and finally sinks, owing to its increasing weight, forming the "Vinegar Mother;" then the formation of acid ceases. If the fermentation is very active after the alcohol is all converted, the resulting acetic acid may itself be attacked and decomposed into water and carbon dioxide. This, however, does not take place if a fresh supply of alcoholic liquor is added. Under the most favorable conditions the ferment cannot live in a liquid containing much more than 13 per cent of acetic acid.

In the Orleans process of making vinegar from wine, oak casks of about 300 litres' capacity are used. The cask is filled about one-third full of strong vinegar containing some ferment, and about 10 litres of wine (previously filtered through beechwood shavings until clear) are added, and the whole allowed to stand at a temperature of from 25° to 30° C. After about eight days the wine has soured, and another portion of 10 litres of wine is added. This

process is repeated until the cask is about half full, when about one-third of the vinegar is drawn off, and the process of adding fresh wine is resumed. This goes on, under favorable circumstances, for several years, until the cask becomes too full of sediment; then it is emptied and thoroughly cleaned by washing and scalding with hot vinegar. The casks have openings at the top for the admission of air, and the fermentation is largely spontaneous.

The action of the ferment may be checked if the temperature falls too low; or if the wine added is very low in alcohol, it may not support the ferment, and the vinegar is decomposed into water and carbon dioxide. The ferment may also be weakened or destroyed by the presence of vinegar eels, Anguillula aceti, a species of microscopic worm, which deprives the ferment of the oxygen needed for its propagation.

The Orleans process is slow, but the resulting vinegar has a fine flavor and aroma.

Pasteur suggested a modification of the above process, in which the ferment is cultivated in a suitable liquid, and the alcoholic liquid is added regularly when the "mother" is well started. When the acid formation becomes slow the "mother" is collected and washed, and used to start a new fermentation.

The "quick vinegar process" is now generally practiced for fermenting malt decoctions, diluted alcohol, or the extract from any fermented mash. The liquid should be clear and free from any sedi-

ment or slime. The fermentation is carried on in tall vats, or casks, about 12 feet high by 5 feet in diameter. These have perforated false bottoms, on which rests the filling of beechwood shavings, reaching nearly to the top of each cask. Over the shavings, a few inches below the cover of the cask, is a perforated wooden plate, through the holes of which short pieces of twine are drawn; 4 or 5 glass tubes are set in this plate, to permit the upward passage of the air. The beech shavings are boiled in water, and then soaked in strong vinegar before filling into the vat. Their purpose is to spread the liquid into thin films, so that the oxidation may be rapid. They also serve as points of attachment for the ferment. The liquid to be fermented, a mixture of dilute alcohol and vinegar, is fed in a slow stream on to the top of the cover, through which it percolates, dripping from the ends of the twine upon the shavings. It comes in contact with the ferment on the shavings, and with the current of air passing up through the mass, and the alcohol is rapidly oxidized into acetic acid. The temperature within the vat rises, causing the acid to rise and escape through the openings in the top, while fresh air enters through holes in the sides of the vat, just on a level with the false bottom, thus causing a continual circulation of fresh air within the vessel. The temperature is shown by a thermometer, and is kept as near 30° C as possible, by regulating the temperature of the air admitted into the cask. If allowed to go too high, much alcohol is lost by evaporation, and the vinegar

is weak. Too rapid an air current also evaporates much alcohol. The vinegar formed collects under the false bottom and flows out through a siphon.

If the liquor does not contain more than 4 per cent of alcohol, it may all be converted by one passage through the vat, but the resulting vinegar is weak. Hence it is customary to add more alcohol, and run the liquor through the cask again. Or, as is often done, it flows through a series of vats.

Exact regulation of the strength and flow of alcoholic liquid, and of the amount of air admitted, is essential to successful working. Pure air and good ventilation of the room are also necessary. Considerable alcohol is lost by evaporation, amounting, even in good work, to about 15 to 20 per cent of that in the original liquid. The air leaving the converters is often washed with water to recover the vaporized alcohol and acetic acid. On an average, the vinegar produced contains about 6 per cent acetic acid, which may be increased to 10 or 12 per cent by proper regulation of the process; there is, however, a consequent diminished yield of vinegar. The time required to produce finished vinegar is from 8 to 12 days. The amount of alcohol added must be so regulated that the liquid leaves the vat still containing a small percentage of unchanged alcohol, for, if it is all converted, the oxidation extends to the acetic acid, and some may be lost through decomposition into water and carbon dioxide. Many accidents cause the process to go wrong, and much care is necessary to secure regularity of product and yield.

If vinegar eels appear it is customary to kill them by adding hot vinegar until the temperature of the vinegar running out of the cask has risen to 50° C.

The vinegars made from different sources vary in color, taste, specific gravity, and other properties.

LACTIC ACID.

Owing to its many uses and applications in the industries, the manufacture of lactic acid, which is closely related to the production of vinegar, is a profitable industry and therefore worthy of consideration.

Lactic acid is now used extensively in dyeing wool as an assistant in mordanting with potassium bichromate. It is also largely used in tanning for removing the lime from the skins or de-liming, as this process is technically known. With its use in spirit manufacture and in brewing as a medium for souring the yeast and securing other advantages the brewer is, of course, fully familiar.

While the present prices induced by the war which this commodity commands are exorbitant, lactic acid now retailing for as much as five to six dollars the pound, its production even in times of peace is profitable and remunerative.

As above stated the manufacture of lactic acid is very similar to that of vinegar. It depends upon the action of the micro-organism known as *Bacillus acidi lactici,* of which many races exist and which by a process of lactic fermentation is capable of splitting up a solution containing grape sugar, or

as it is commonly known, dextrose, into lactic acid, one molecule of dextrose yielding in this way two molecules of lactic acid.

At the present time various methods very much similar in their essentials are employed, and we shall describe here only the method originated by Avery in 1881 (English) and known as the Avery process, and also the German method of manufacture as it is used on the Continent.

Avery's Process.

Preparation of Sugar Containing Solution. This solution should have a specific gravity of 1.05 to 1.075 and should contain from 7½ to 11 per cent of glucose. It is advantageous to replace 10 to 15 per cent of the glucose by cane sugar, which is progressively inverted by the lactic acid, and this continually furnishes fresh matter for the bacillus. The solution must also contain nitrogenous matter as food for the bacillus, amounting to at least 2 parts of nitrogen to 100 parts of sugar. For this purpose the addition of vegetable albumen, made by extracting bran with boiling water and acid, is very suitable. Mineral nitrates and ammonium salts may also be used.

Process of Inoculation. The sugar containing solution as described above is boiled one hour to sterilize it, rapidly cooled to from 55° to 45° C, run into a fermentation vat and inoculated with the lactic bacillus. In continuous manufacture this inoculation is carried out by running in 20 per cent or more of the

preceding fermenting liquor, in which a lively fermentation is in progress. For the original inoculation a good culture of lactic bacteria must be obtained by allowing milk at 45° C to stand until slightly sour. A pure culture is usually obtained by inoculating previously sterilized milk, kept at 45° C, with a good lactic acid bacteria obtained from the bacteria in the fermentation tank.

Fermentation. During fermentation the temperature of the sugar solution should be held at 45° to 55° C in order to prevent the development in the solution of butyric acid or alcoholic ferments. Since the lactic acid bacillus cannot flourish in solutions containing more than 1 per cent of lactic acid, the acid as it is formed must be continually removed by neutralization, which is accomplished by the addition of lime water in such proportion as to keep the lactic acid within the limits of 0.02 to 0.5 per cent. If the neutralization is carried further butyric infection may take place, which will result in a low yield. The fermentation should proceed vigorously and be completed in from three to six days, at which time 98 per cent of the sugar should be used up. The liquor, which now consists of a solution of calcium lactate, is then heated to kill all bacteria and spores, filtered, and evaporated. Pure lactic acid is obtained by repeated crystallization of the calcium lactate, but commercial lactic acid is obtained merely by decomposing the uncrystallized solution by sulphuric acid. The free sulphuric acid is then filtered from the precipitated calcium sulphate, which is

practically insoluble in the dilute lactic acid, and evaporated to a 50 per cent solution, forming a brownish syrupy liquid having a specific gravity of 1.20 and containing about 7 per cent of anhydrous lactic acid.

German Methods.

In Germany the solution of grape sugar is always made from a mash of starchy materials, corn, potatoes, rice, etc., by mashing with a small amount of malt in order to convert the starch into maltose, the process being similar to that employed in spirit manufacture. The lactic acid bacillus employed in the largest German factories is the *Bacillus acidi lactici*, Hueppe, forming short thin rods, linked together in chains, and sporeless. A pure culture of this bacillus is obtained by the ordinary methods of bacteriology from sour milk or cheese, using as growing medium a solution of 100 parts of grape sugar, 1 part dried peptone, 0.2 part of potassium hydrogen phosphate, 1 part sal-ammoniac, 50 parts of powdered chalk, and 600 parts of water.

The fermentation is carried out very similarly to the method employed in Avery's process, at a temperature of 45° C, but the time of fermentation is longer, usually ten to twelve days. At the end of this time the absence of sugar is proved by Fehling's solution, the liquid is then made faintly alkaline by lime water, boiled, filtered, and evaporated to 15° Beaume, when calcium lactate crystallizes out. This is removed by means of a filter press, while the dark

mother-liquor and washings are again evaporated to 15° Beaume and allowed to crystallize. The black mother-liquors remaining from this second crystallization are discarded.

The calcium lactate is purified by crystallization and decomposed by sulphuric acid, filter-pressed from the precipitated calcium sulphate, and the solution of the acid concentrated by evaporation. If a clear lactic acid solution is required, the warm solution of lactic acid as it comes from the calcium sulphate filters is pumped into tall wooden or leaden cylinders filled with animal charcoal, and after having been left there for a number of hours is drawn off at the bottom, filtered through felt cloth, and evaporated so as to contain 50 per cent of acid. This yields commercial lactic acid.

The manufacture of chemically pure lactic acid from the above crude product requires considerable machinery and careful work, and therefore cannot be recommended for the brewer, especially inasmuch as there is a good market for the crude product.

Chemically pure lactic acid is obtained from the commercial product as follows: The calcium lactate obtained as described above is decomposed by zinc carbonate, whereby the sparingly soluble and easily crystallizable zinc lactate is obtained. The pure zinc lactate is then decomposed by hydrogen sulphide, filtered from the zinc sulphide, which is a difficult operation, and is then evaporated in an enameled vacuum apparatus, when clear, pure lactic acid is obtained.

There are of course a large number of other methods which are commercially employed for refining the crude acid, but it would be unwise to discuss them here. Brewers interested in the manufacture of lactic acid should consult the bibliography, which furnishes much additional information on this subject.

THE FERMENTATION OF VINEGAR.

Briefly Reviewed by Paul Hassack.

Etymologically the significance of the word "vinegar" means soured wine and was originally employed in this exclusive sense in the definition of this substance as a product of a natural phenomenon, the causes and character of which, for many thousand years, was a puzzle to scientists throughout the ages until Pasteur, about the middle of the past century, recognized and proved it to be due to a biological process of assimilation caused by micro-organisms, termed Vinegar Bacteria; by the activity of the bacteria the alcohol present in fermented fruit juices such as wine, hard cider or others, as well as in fermented malt or cereal mashes, and even diluted distilled alcohol is caused to undergo the acetic acid fermentation.

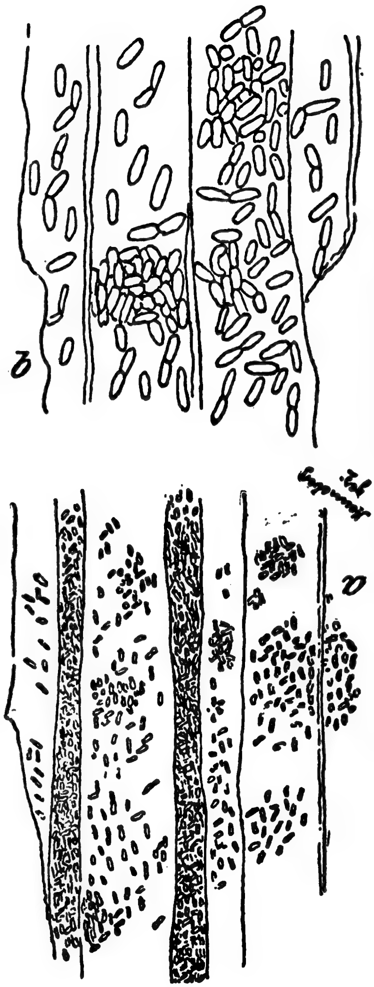
As regards the present conception of what constitutes vinegar, this is clearly outlined in the rules and regulations for the enactment of the Food and Drug Act of June 30, 1906, and particularly defined in Circular 140 of the United States Department of

Agriculture of February 27, 1912, which reads in extract as follows:

1. Vinegar, cider vinegar, apple vinegar, is the product made from the alcoholic and subsequent acetous fermentations of the expressed juice of apples.
2. Wine vinegar, grape vinegar, is the product made by the alcoholic and subsequent acetous fermentation of the juice of grapes.
3. Malt vinegar is the product made by the alcoholic and subsequent acetous fermentations, without distillation, of an infusion of barley malt or cereals whose starch has been converted by malt.
4. Sugar vinegar is the product made by the alcoholic and subsequent acetous fermentation of solutions of sugar, syrup, molasses or refiners' syrup.
5. Glucose vinegar is the product made by the alcoholic and subsequent acetous fermentations of solutions of starch sugar or glucose.
6. Spirit vinegar, distilled vinegar, grain vinegar, is the product made by the acetous fermentation of dilute distilled.

All of the products above described should contain not less than four grams of acetic acid per one hundred cubic centimeters, to come within the definitions of the laws.

The impure product made by the destructive dis-



Vinegar Bacteria as seen under low and high power microscope.

tillation of wood, known as "pyreligneous or crude acetic acid" is not vinegar nor suitable for food purposes.

The product made by diluting re-distilled or refined concentrated acetic acid (Acidium glaciale) is not vinegar and when intended for food purposes must be free from harmful impurities and sold under its own name; it must not be branded vinegar, and if so is considered an adulteration.

The manufacturing of vinegar by fermentation constitutes an extensive special field and but a general outline of its most important branches could be condensed into the limited space of this work.

Anyone who desires to acquire thorough information about it is referred to my special treatise, "Gaerungsessig," 1904, or to my latest publication, "The Vinegar Bulletin," 1917.

In the course of the acetous fermentation oxygen is conducted to the alcohol in the form of air and through the medium of the vinegar bacteria the alcohol is oxidized into acetic acid, a process comparable with the biological function of yeast in decomposing sugar into alcohol and carbon dioxide in the alcoholic fermentation.

The change of matter occurring in the course of the acetous fermentation is best illustrated by the chemical formulas of both alcohol and acetic acid and the comparison of the atomic weight of both substances.

Alcohol has the composition:		Acetic acid has the composition:	
Formula:	Atomic weight:	Formula:	Atomic weight:
C 2	24	C 2	24
H 6	6	H 4	4
O	16	O 2	32
Total	46	Total	60

It is clearly shown by this example that 46 parts by weight of alcohol yield 60 parts of acetic acid, which in proportion to 100 parts is the equivalent of one pound of alcohol yielding theoretically one and three-tenths pounds of acetic acid. The increase in weight is attributed to the absorption of one atom of oxygen against the loss of two atoms of hydrogen.

In practical commercial work these yield figures are, with the present stage of any applied process, only obtainable within about 70 per cent of the theoretical yield and while 1 lb. of alcohol should yield 1.3 lbs. of acetic acid we do not obtain more than 0.91 to 0.97 lbs. in actual practice. But in one single laboratory experiment carried out on a commercially large scale I had occasion to experience 1.15 lbs. of acetic acid from 1 lb. of alcohol. The reported results were made possible by artificial aeration and reclaiming of the major part of the alcohol and acetic acid vapors, which in the regular course of fermentation constitute an inavoidable loss.

From practical experience I am able to state that about 1.3 gallons of absolute alcohol (100 per cent) must be employed in practical work in order to pro-

duce 10 gallons of 10 per cent vinegar, which means about 0.95 lb. of acetic acid from 1 lb. of alcohol.

In other words and by reversing the figures we get from 1 gallon of absolute alcohol weighing 6.66 lbs. in the best case, but 8 gallons of 10 per cent vinegar containing about 6.64 lbs. of acetic acid by taking the round weight of 8.3 lbs. per gallon vinegar as the basis.

There are two distinct methods of manufacturing vinegar in commercial application.

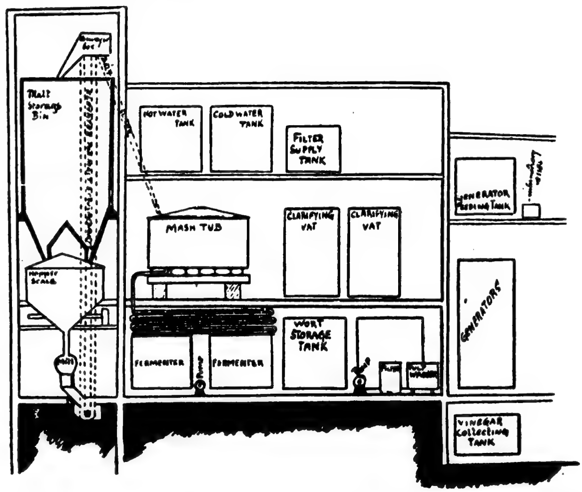
1. The Orleans process; 2. The quick vinegar generating process.

The old Orleans method which was used for centuries in the slow acetification of grape or fruit wines, and also for cider and malt vinegar making. The process consists principally by filling barrels about three-fourths full with the wine or fermented cider, with the bung of the barrel left open and a few additional holes drilled in both barrel heads slightly above the liquid level. These barrels, in place of which also wide and low containers can be applied, are stored in warm cellars or artificially heated rooms. A few days after exposure of the liquid to the free access of warm air, colonies of vinegar bacteria will be visible to the naked eye in the form of a thin veil cohesively covering the entire surface of the liquid. The atmospheric air having free access and circulation over the exposed surface is eagerly made use of by the bacteria in the transformation of the alcohol into acetic acid.

The bacteria growth on the liquid surface gradually grows heavier and sinks to the bottom with the

least concussion which the liquid at times might be exposed to, and a new veil forms.

All skin forming vinegar bacteria thriving on the surface of alcoholic liquids are by their nature not adapted to great efficiency in producing large quantities of acetic acid under prevailing floating conditions, in consequence of which it takes at times



Sketch Showing Layout for Malt Vinegar Factory on Gravity Plan. (From "Vinegar Bulletin".)

from four to six months before all the alcohol in the three-fourths barrel is converted into vinegar.

It has been determined that a liquid surface exposed to oxidation of 1.2 square yards is but productive of one-half pound of acetic acid in 24 hours (which is the equivalent of a little over 1 gallon 5 per cent vinegar).

Were it not for the extreme slowness of the Orleans method, it must be admitted that the quality of the products' relative aroma is unexcelled, and for this sole reason the method has not as yet come out of use in the manufacture of the highest grade of French grape vinegar. English malt vinegar manufacturers who extensively used the process have altogether abandoned this method and turned to the so-called quick process of generating the vinegar.

Cider vinegar is frequently made on farms by exposing partly filled barrels or kegs with fermented cider to spontaneous acetification by the described slow process.

The Quick Vinegar Generating Process.

It is almost 200 years according to available data that the application of a vinegar generator is mentioned in the annals of vinegar making. The progressive thought of accelerating the low process is evident.

At first, same as at present, upright casks or tanks of moderate diameter were used for this purpose.

These were loosely packed with the skins and stalks of pressed grapes, which offered a good soil for vinegar bacteria to colonize and propagate. The cask was either entirely or only partly filled with the wine or cider, and after 12 hours the liquid drawn off and filled into an adjoining generator. Number one remained empty for 12 hours and was then filled up with the vinegar stock of number two.

During the period any of these two generators stood empty, intensive oxidation of the alcohol into vinegar took place and gave evidence by increased temperature, through the energy of the acetous fermentation. By alternately operating in the described manner in shorter or longer intervals about three times as much vinegar could be produced than by the Orleans method.

In 1823 a vinegar maker in Ausburg improved this still slow method and created by a mighty simple deed the present universally adopted quick vinegar generating process.

Schuetzenbach was the first to realize the all importance of atmospheric air as an oxidizing medium and by drilling some small holes near the bottom of the generator he succeeded by this, in itself simple but logical execution of principle, in creating artificial aeration of the porous generator packing by natural draught. The vinegar stock percolating in periodical pourings slowly in a downward direction was made to meet a continued current of atmospheric air with an even course of fermentation and greatly multiplied production as the result.

Vinegar making has been until about 15 to 25 years ago more or less a stepchild among modern industries, and only since scientific research has joined hands with the practical, more or less empirically working manufacturer, a noteworthy uplift of this industry is discernible, evidence of which is the greatly extended bacteriological knowledge and the substitution of manual labor in vinegar facto-

ries by vastly improved mechanical, automatically operating infusion devices.

The wine stalks originally used as generator packing were replaced by the spiral and porous red beech shavings and equipped with other modern attachments originated within the past years, the quick vinegar generator of the present age, immaterial of what its dimensions might be, is under careful control an apparatus of mechanical perfection applicable commercially on even the largest scale in the manufacture of whatsoever kind of vinegar.

It is believed that this brief review of vinegar manufacturing gives a general outline of all cardinal points of interest to those who wish to inform themselves in a general way of the general principles and features of this industry.

VI. Malt Flour, Malt Extract and Diastatic Preparations.

Malt Flour. Malt flour or diastatic malt flour is prepared by crushing malt between fluted rolls and passing it through sieves to take out the husky or cellulose matter. The malt being very dry, the husk breaks up into fine and coarse particles, the latter only can be removed by the sieves, hence malt flour always possesses a brownish-gray shade of color. Malt flour freshly prepared is a very hydroscopic substance, which rapidly absorbs moisture from the air and soon loses its characteristic flavor and smell. It ought to be sent out in air-tight drums instead of in the canvas bags used at present. Brewers, who are aware of these facts, are careful to keep whole malt in dry, warm stores until required for use, and only crush the malt a few hours before brewing. Bakers who stock malt flour in any quantity would be wise to follow the example of the brewers in this way, as they would then preserve the fine flavor of the malt and run less risk of the excess acidity which is so commonly present in slack malts and badly-stored malt flour.

Malt Extracts and Diastase Pastes. The principal point of difference between these substances is that in the malt extracts the diastase has been already used to prepare the extracts and is, therefore, present only in small proportions and weakened; whereas in diastase paste it is fresh, vigorous, and

active. The extracts are prepared by hot water mashing, whilst the pastes are cold-water extractives.

In the manufacture of malt extract the malt is crushed between fluted rolls and then mixed with water of such a temperature that the resultant temperature of the mixture will be about 145 degrees F., which is the point of maximum activity for diastase. Every 100 lbs. of malt require about three to three hundred and sixty pounds weight of water. The mixture, which has a consistency of thin porridge, is allowed to stand in the mash tub for about three hours so as to insure the conversion of the starch of the malt into maltose and dextrins, and to modify suitably the nitrogenous bodies. This "wort" or sugar solution is run off into a tank, and any sugars remaining in the grains are washed out by sparging. After settling for a short time the wort is passed through a filter press, and from this into another smaller settler adjoining the vacuum pan. From this, after some time, the thin liquors pass by suction into the pan and are boiled down to the proper consistency at a reduced pressure, such that the temperature is between 132 degrees and 135 degress F. The thick syrup is now ready to be run off into the drum in which it is sent out into commerce. The value of a malt extract depends on the quantities of malt sugar or maltose, soluble nitrogenous compounds and mineral salts present. Its chief value lies in its stimulative effect on the yeast in fermentation.

Diastase pastes, as previously stated, are cold-water extracts of malt.

The malt is crushed and made into a thin porridge with cool water, so that the temperature of the mixture is about 70 degrees F. This mash is allowed to stand in the mash tub for five hours, so that as much soluble matter as possible is extracted from the finely divided malt. All the liquor is run off, and both this and the grains passed through a filter press. The liquors are settled and then boiled down in the vacuum pans as described in the preparation of malt extracts. Some slight modifications are necessary so that different strengths of diastase paste may be obtained. Cheap, low-grade pastes are prepared from inferior barleys and malts; whilst for the highest grade only the best barleys, English and foreign, after careful malting, can be employed.

Diastase pastes depend for their value not only on the carbohydrates and soluble nitrogenous constituents, but on the quantity and activity of the diastatic enzymes. Other soluble ferments or enzymes are present, but they are of less importance than the diastase. Yet even these should not be overlooked as they have considerable effect on the gluten and possibly other substances, resulting altogether in shortening the time in which the dough is ready for the oven. Diastase can only act on gelatinized or soluble starch, therefore the wheaten starch granules are unaffected by it, but as soon as they become gelatinized the starch-flour or granu-

lose is at once acted upon and converted. Wheaten starch granules in presence of moisture burst or are said to be gelatinized at about 170 degrees F. Diastase action is stopped in the moist state at 176 degrees F., so that it will be seen there is little opportunity for diastatic action after the dough is in the oven. It is enough, however, to have a marked effect on the finished loaf.

Of the three malt products described, diastase pastes are the best and most useful. The quantities employed vary from a half to a pound and a half per sack of flour. These quantities, however, may be increased with advantage to from two to three pounds per sack, especially with strong flours and short processes, without causing extra difficulties in manipulation. The Author found that almost all grades of bread were very much improved by using rather higher proportions. Practically all the desirable properties of a loaf were much enhanced. The only question to be considered is the extra cost to the baker.

The advantages to be derived from the use of diastase pastes may be summed up as follows:

Externally, the bloom curse, value, and the general appearance of a loaf are all improved.

Internally, the flavor—a kind of sweetness is imparted—the appearance of the crumb, and the moisture after several days' keeping, are all benefited by diastase pastes. If examined for food value, a malted loaf will be found to possess many heat-calories more than the ordinary unmalted bread;

further, such bread is much more readily digested. Malt flour, which is more easily handled, cannot be introduced in larger quantities than about a pound to a pound and a half per sack without spoiling both the external appearance and the crumb of a loaf. All three classes of malt products increase the volume and give more spring to the loaf in the oven.

A high-class, friable malt will yield about 67 per cent of extract; or, in other words, 300 lbs. of malt should give 200 lbs. of extract.

This extract, when used in breadmaking, assists in degrading the flour, feeds the yeast, and so quickens fermentation.

In the long bread processes it is better to use a diastase paste in the earlier stages of fermentation and a malt extract in the later stages. With strong harsh flours both are invaluable, as they mellow and tone down the gluten.

Weak flours, which contain a fair proportion of food for the yeast, do not require these extraneous aids, and, moreover, such flours will only be rendered weaker by them. If they are used the quantity should not exceed four ounces per sack of flour.

The fluid malt products must be kept in cool places, otherwise they readily ferment, lose their diastatic power and maltose, and gradually increase in acidity until they become sour.

VII. Industry of Breakfast Foods.

By C. A. Nowak.

SO far most of the chapters have concerned themselves largely with the adaptation of the breweries to the manufacture of beverages other than beer and other commodities. As brewery after brewery gradually enters the rank and file of some of the other industries it is only natural that the demand for malt will soon drop off. The maltster, therefore, is confronted with the same problems as the brewer, namely, what products could he manufacture whereby all of his plant could be utilized without necessitating enormous expenditures in new equipment.

The maltster having no cellars in his plant, beverage manufacture does not appear a feasible solution of his difficulty. Besides he has enormous floor space and is accustomed to handle more or less bulky material. It is of course possible to utilize malt in milling for the manufacture of malt flour, but the demand for this material at the present time is so small that this field offers no satisfactory solution of the problem. It is a generally accepted fact that the employment of small quantities of malt flour as an adjunct in the baking industry will yield a more satisfactory loaf of bread than can be obtained without its use; however, the baker in general is not familiar with the properties of malt flour, and unless he is first educated to the

correct method of employment he is bound to fail in his attempts, which possibly accounts for the aversion that some bakers have toward the employment of this material.

Recently maltsters have been seriously considering the engagement of a good chemist whose mission it would be to find or to develop new uses for malt. There is little doubt that conscientious efforts in this direction will bear fruit, but until such uses are found the maltster will do good in devoting his energy to the development of the malt flour industry, the employment of malt in the manufacture of maltose sugar or syrup, the manufacture of malt extracts, and hand in hand with these the development of new breakfast foods from malt. Flour milling and the manufacture of breakfast foods offer the additional inducements that the by-products obtained can be worked up into very satisfactory cattle feeds, an industry by itself to which another chapter has been devoted.

The manufacture of cereal breakfast foods from malt is in its infancy, and offers large possibilities. At the present time most of these breakfast cereals on the market consist of rolled, puffed, cooked, or partially cooked or otherwise heat-treated cereals. According to Professor Sherman, an authority on food chemistry, all of these materials resemble closely the staple grain products from which they are manufactured both as regards composition and nutritive value. It is also generally known that most of the claims made by the manufacturers are

exaggerated. It may be of interest to quote from Dr. Harvey W. Wiley, formerly chief of the United States Department of Chemistry, who treats this subject in his book entitled "1001 Tests of Foods, Beverages and Toilet Accessories."

"Many are the letters received in regard to the cereal breakfast foods, especially for children's use. One mother writes me: 'Two small youngsters are anxiously awaiting your opinion in regard to their favorite shredded wheat, grape nuts, and post toasties.' With few exceptions, a general statement will serve to give the facts in regard to all of the leading brands of cereal products and breakfast foods sold in packages. They are nutritious, clean products, containing the greater part of the nutriment of the grain and in some cases all of it. They are put up in a sanitary package and are convenient, and afford variety. You do not get anywhere near as much nutrition for the same amount of money as when you buy the simple grains, such as whole wheat, cornmeal, oatmeal, etc., in bulk. If you realize this, however, and are willing to pay for the convenience and variety, there is no reason why they should not be used. The cornmeal and oatmeal are somewhat heavy and heating, so that unless a person is doing heavy, physical work, it might be well to use a less concentrated food. The whole wheat and the old-fashioned oatmeal and cornmeal can never be surpassed or equaled as wholesome economic foods, giving the greatest amount of nutriment for the smallest amount of money. It must

be remembered that the amount of nutrition present is not the only point involved in wholesomeness and the coarser form of the natural grains and the presence of bran have a beneficial effect upon the bowels as well as furnishing additional mineral ingredients.

"The processing of foods by 'predigesting' and grinding, in my opinion, renders them relatively less wholesome though not less nutritious, inasmuch as performing the work of the teeth and the digestive organs for them decreases their activity and in time affects their functioning if it is carried too far. Nevertheless, the moderate use of the package cereals is an undoubted boon under our present conditions of life, and they may fill a valuable and convenient place in the dietary, if not used exclusively.

"The most serious charge to be brought against package cereals is the exaggerated claims made for their nutritive value. One becomes confused among so many products, each one of which is 'the richest in nourishment,' 'the most easily digested, even by chronic invalids,' 'immediately converted into muscle and brain activity,' etc., etc. Oatmeal is the heaviest of cereals and still so excellent a brand as Hornby's Steam Cooked Oatmeal claims to be 'Good for invalids and those with weak stomachs,' merely because it is thoroughly cooked.

" 'The Road to Wellville' is to be traveled by eating Grape Nuts, a meaningless name applied to a mixture of cooked barley and wheat. The analysis

of this product shows it to contain a very fair amount of protein, about 11 per cent, with an equal amount of sugar, and no more mineral ingredients than any wheat and barley mixture should have. There are no 'Brain foods' as such. It is a great pity for these products to be burdened with such senseless exaggerations as to leave the consumer in the dark as to the relative merits of different grains and the special conditions under which they should be used."

Inasmuch as there is not much to be said about the manufacture of cereal breakfast food the author wishes to refer to the bibliography on this subject which likewise, unfortunately, is very limited, and to devote the rest of the chapter to the details of a new method developed by him for the manufacture of a malt cereal breakfast food, of which, to his knowledge, there is nothing similar on the market. This product consists of a suitable raw cooked cereal flavored with malt or caramel malt and thereupon further caramelized by means of heat, and dried.

In the first experiments the well cooked raw cereal was flavored by means of an extract of caramel malt prepared in the manner known to brewers and then dried and further caramelized. This process, however, is both troublesome and wasteful inasmuch as a regulation mash has to be made with the addition of pale malt to effect saccharification and furthermore this mash must be filtered from the grains, the clear solution only being used. Later experiments showed that practically just as good re-

sults could be obtained at a great saving of time, cost and labor, by merely grinding the malt separating the husk by screening or bolting, and adding the caramel malt flour directly to the cooked cereal incorporating it thoroughly therein, and continuing the cooking operation until the desired result has been obtained. The material is now spread upon the drying frames, or plates, which should be of burnished tin or similar material in order to minimize as far as possible the tendency to adhesion which is a characteristic of the dried product. The taste of the product is easily controlled by the operator, but to obtain a uniform product a thermometer must be installed. By controlling the temperature a smaller or larger portion of the starch may be converted into maltose and dextrine exactly as may be desired. After the product is dry it should be crushed to the desired extent by passing the same through a mill or through rollers.

The product obtained in this manner should be a brown crisp material, resembling to a certain extent the product known as "Grape Nuts."

In a brewery where a rice cooker such as used in brewing is available, this may be used for cooking the grain so that all that is required are the proper facilities for drying and the cooked material. By regulating the temperatures in the drying operation, products differing widely in point of taste can be obtained from the same raw material. This is a marked advantage when it comes to selling the product. Most people using breakfast foods desire

a variety, and it really does not take long before one tires of a certain prepared cereal. In producing a product of the above type, the manufacturer can without additional trouble produce a variety of grades to be put up in different colored packages. For instance, one grade could be made so as to possess only a slight malt and caramel taste, another grade a medium malt taste, and another grade a very strong and pronounced malt taste.

A drier is about the only piece of apparatus which would have to be installed. For experimental purposes it would suffice to have a drying chamber constructed on the premises and at practically very little expense. This drier should consist of a wooden tin or asbestos lined chamber fitted with live steam coils, exhaust fan, operated by a small motor and a rack with sufficient shelves to accommodate 8 to 10 drying frames or plates which should be readily removable from the rack. The frames should not be more than 24 inches or 26 inches, as they are of metal, and if much larger, very difficult to handle. The drying chamber should further be provided with air vents on the side opposite the exhaust fan. It should further be provided with a door, by means of which the operator can insert, or remove from the drying rack, any one of the frames without entering the chamber which must be maintained at a fairly high temperature, the latter depending entirely upon the flavor which it is desired to impart to the breakfast food.

VIII. Commercial Feeding Stuffs.

By C. A. Nowak.

THE manufacture of concentrated feeding stuffs or, as they are sometimes termed, "compound feeds," as an industry, is still in its infancy, in spite of the fact that there are numerous preparations of this sort now on the market and are being sold to farmers at a big profit. However, all of these products as they can be found catalogued in the various Agricultural Station Bulletins are compounded and placed upon the market by firms or individuals who are practically ignorant of the fundamental principles of cattle feeding and therefore, in many cases, are not what they should be, and in other cases their manufacture and sale does not net the profits which could be realized if the exact requirements were fully understood by the producer.

It does not require lengthy arguments to convince anybody who is at all progressive that a malt house going into the manufacture of these products in a thorough and scientific manner could not only do wonders in working up this new industry, but would at the same time find it to be a very remunerative undertaking. Of course this would require an appreciable investment, the installation of milling machinery, and the establishment of a laboratory and the engagement of a capable research chemist to develop new products and to control the materials produced, which must be scientifically compounded. The

manufacture of concentrated feed offers a big field for research, and if the appropriation for laboratory and research work would allow this, an experimental farm and stable where actual nutrition experiments could be made at very small additional expense, would at once bring the plant into the foreground as the leading manufactory in this new field.

The object of the present chapter is not to go into the manufacture of the various feeding stuffs in detail, but merely to discuss briefly some of the underlying principles. The scientific manufacture of cattle feeds is a big field and a thorough understanding and mastery of the subject requires a good knowledge of the fundamentals of chemistry, a careful study of the various principles involved and a close application.

The main raw materials to be dealt with in this chapter have been limited to those which enter into the manufacture of concentrated foods and which consist of (a) seeds—cereals, pulse, and oily seeds; (b) oil cakes, compound cakes, and meals, and (c) commercial by-products, e. g. from milling, brewing, distilling, starch, and sugar industries.

Principles of Cattle Feeding.

Broadly speaking, the value of any feeding stuff depends upon its content of protein, fat, and carbohydrate. Whenever a feeding stuff is submitted for complete analysis it is customary for the chemist to determine the following six constituents,

viz.: Crude protein, crude fat (sometimes stated as ether extract), soluble carbohydrates (also known as nitrogen-free extract), crude fibre, largely cellulose, moisture, and ash, this last representing the mineral matter.

Protein, fat, and carbohydrate, all constitute what is technically termed *Nutrients*, that is they are all substances which to a greater or lesser degree possess nutritious qualities. However, experience has shown, and science has demonstrated, with a considerable degree of exactitude, that all of the nutrients present in a feed, or food, as the case may be, are not completely digestible, a portion of them being eliminated through the intestinal tract without having been assimilated. In other words, there is a loss which imparts to manure its fertilizing properties.

Experiments have demonstrated that the nutrients in food, depending upon their origin, are capable of different degrees of assimilation by the animal or human organism. In other words, the loss or amount of unassimilated nutrients in two foodstuffs, even if they contain the identical amounts of protein, fat, and carbohydrate, will vary considerably, depending entirely upon the nature and the character of the feeding stuff. Digestion trials, to show what per cent of each nutrient in different feeds is digestible, have been made and collected in tabular forms and are known as *Coefficients of Digestibility*. These coefficients of digestibility have been so tabulated as to state to what extent each of the nutrients in the food in question is digestible. As an

example of a substance with which we are all familiar, let us take dried brewers' grains. By looking this feed up in the tables appended to practically all Agricultural Station Bulletins devoted to feeding and feed analysis, we find that 81% of the total protein, 89% of the total fat, 57% of the nitrogen free extract (this means soluble carbohydrates) and 49% of the total crude fibre are digestible.

If we now proceed to look up in another table giving the analysis of various feeding stuffs the percentages of total protein, total fat, total N-free extract, and total crude fibre and multiply these by their respective coefficients of digestibility we arrive at what is technically known as *Digestible Nutrients* of the feed in question.

Again using dried brewers' grains as an example we find that these contain on the average of 25% crude protein, 13.6% crude fibre, 42.3% N-free extract, and 6.7% fat. Accordingly, the digestible nutrients of dried brewers' grains would be as follows:

	Total Amount Present		Coefficient of Digestibility		Digestible Nutrients
Crude Protein	25%	×	81	=	21.6
Crude Fibre	13.6%	×	49	=	6.7
N-free Extract	42.3%	×	57	=	23.0
Fat	6.7%	×	89	=	6.0

At the outset of this paper it has been said that it is customary for the chemist to report the total amounts present of the six different constituents there enumerated. Five of these are determined directly, but the percentage of the Nitrogen-free extract, or soluble carbohydrates, is obtained by subtracting the sum total of all the other constit-

uents from 100. This N-free extract may include a number of different organic substances, like sugar, starch, dextrines or gums, pentosans, organic acids, etc., most of them carbohydrates, and, therefore, by adding this N-free extract to the percentage of crude fibre, we obtain the sum total of all the various carbohydrates present in the feed.

Now, inasmuch as in feeding for any specific purpose—maintenance, work, milk production, or increase—as the case may be, certain minimum amounts of digestible protein and digestible non-nitrogenous nutrients are required, these facts must be taken into consideration in scientific feeding. To accomplish, or rather to attain, any of the above mentioned results it has been found that protein and carbohydrate must bear a definite ratio to each other. As Mr. Wittemann correctly states, if there be a deficiency of either kind of nutrient, even if the other be present in excess, there will be a loss, a waste so to speak, and the object of the feeding will not be satisfactorily accomplished. While it has been found that an excess of protein is a fair substitute for non-nitrogenous nutrients, and has approximately the same value as an equal weight of starch, it is far more expensive and, therefore, not satisfactory for economical reasons. Lack of proper understanding of this most fundamental principle of scientific feeding is responsible for the fact that the value of dried yeast as an addition to feeds of inferior quality has been vastly underestimated in this country. The indiscriminate feeding of dried yeast, owing to its high cost, is

economically impossible. However, yeast is not to be fed indiscriminately but scientifically. As Mr. Wittemann puts it: "An examination of the food value of dried yeast makes it apparent that only small quantities of it added to inferior bulk food brings its feed cost within the reach of general consumption. . . . It contains no waste, tests having proven that over 90% is assimilable in the animal body."

The ratio of non-nitrogenous to nitrogenous nutrients in any food is called the *Nutritive-Ratio* of the food. In order to determine this ratio, the non-nitrogenous nutrients must all be expressed in terms of one of them—starch. The amount of fat must therefore be multiplied by a factor which represents the value of fat as compared with starch. Since fat has about 2.25 times greater fuel value than N-free extract (starch and similar compounds), it is customary to multiply the per cent of digestible fat by 2.25 and to add the product so obtained to the percentages of digestible N-free extract and fibre, which are known as carbohydrates.

Coming back to our original example we would arrive at the nutritive ratio of dried brewers' grains in the following manner:

Digestible Nutrients

Fat	6.0 × 2.25 =	13.5
N-free Extract	23.0	23.0
Crude fibre	6.7	6.7
Total non-nitrogenous nutrients figured as starch		43.2
Crude Protein		21.6

Therefore, by a simple equation—

$$43.2 : 21.6 :: ? : 1$$

The ratio is, therefore, 2 to 1, which would be considered a very narrow nutritive ratio. We may add here that a feed or ration having much crude protein in proportion to carbohydrates and fat combined is said to have a *Narrow Nutritive Ratio;* if the reverse is the case, it is said to have a *Wide Nutritive Ratio.*

On a farm a *Ration* is the amount of feed allowed to maintain a given animal during a day of 24 hours, it being immaterial whether all thereof is fed at one time or in portions at different times. A *Maintenance Ration* is one that furnishes a sufficiency of each and all of the several nutrients, but no more than is required, in order to maintain a given resting animal so that it will neither gain nor lose in weight.

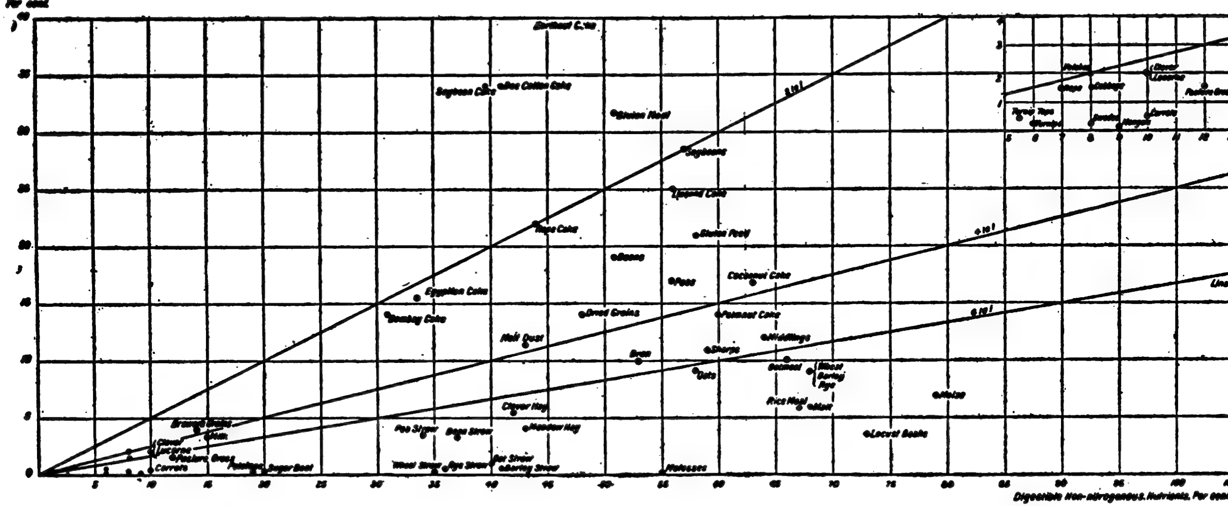
The N-ratios of feeds are of considerable importance in judging the suitability of the feed for any specific purpose, also whether one food can be used to replace another, and, if so, in what relative quantity. They are used also in some of the calculations in compounding rations from two or more different feeds. The compounding of rations falls somewhat without the scope of this article and is a study by itself requiring a thorough knowledge of the physiological and chemical principles underlying scientific feeding.

One point, however, still remains to be mentioned and in view of what has been said is of considerable interest, namely the starch value of various

feeds. We have stated above that fat has approximately 2.25 times greater fuel value of fat-forming power than starch. To be exact this figure varies about 1.91 and 2.41, depending upon the source of the fat, that is, whether it is contained in coarse fodders, cereals, or oily seeds. Nothing, however, has been said of the starch value of digestible protein. According to Kellner, the relative fattening powers of protein and starch are as 0.94 to 1. In general, when we speak of the starch value of a food, we mean the amount of starch which is equivalent to the total fat-forming power of all the nutrients in it. This starch value of food is determined by multiplying the percentages of the digestible nutrients by their starch equivalents, and deducting from the sum of the products a certain percentage which represents the amount spent on the work of digestion.

However, this paper has not been written with the point in view of discussing in detail the theory of the scientific feeding of cattle. What the Author endeavored to show is that the economical feeding of cattle is a science, just the same as is brewing, and that in order to fully appreciate the true value of any of our by-products as a feeding material, we must know at least something of what the requirements of a feeding stuff are. Dried yeast unquestionably is one of the most highly concentrated sources of nitrogen, and if it is to be used in feeding rations or in the compounding of patent feeds, the actual compounding must be scientifically conducted, otherwise a large percentage of the val-

NATURAL CLASSIFICATION OF FEEDING STUFFS.



uable nitrogenous nutrients will be incompletely utilized.

The chart here reproduced has been taken from "The Chemistry of Cattle Feeding," by J. Allan Murray, and shows at a glance the nutritive ratios as well as the percentages of digestible protein and non-nitrogenous nutrients contained in any of the various feeding stuffs tabulated. By referring to the chart it is possible to compare any one food with another, or all together at a glance.

A few words of explanation as to the significance of the chart may be in place. Murray has found it convenient in practice to take the percentage of digestible protein and of digestible non-nitrogenous nutrients—the latter being all reckoned as starch—and from this data to plot the positions of the foods on the chart. For this purpose the protein is plotted on the abscissae (vertical lines) and the non-nitrogenous nutrients on the ordinates (horizontal lines). Consequently, the greater the percentage of protein in a food the higher up will be its position on the chart, and the greater the percentage of the non-nitrogenous nutrients the further to the right.

Three diagonal lines are drawn from the point of origin representing the ratios of 2 to 1, 4 to 1, and 6 to 1, respectively. The chart, therefore, shows the nutritive ratios as well as the percentages of digestible protein and non-nitrogenous nutrients.

Feeding Value of Dried Yeast.

By R. A. Wittemann.

In 1915, I started out on a regular campaign

among feeders of domestic animals, so as to prove the value of dried yeast in that direction. I found dozens of farmers, dairymen and animal raisers very much inclined to try a quantity of yeast, and it taxed the small capacity of our experimental machine for a long time. I realized that it would take long years of education to convince the feeders that dry yeast was not to be compared with ordinary feeds; that they should not expect to obtain it at prices of ordinary feeds, and that concentration necessitated careful study of the quantity to be allotted to each animal, considering the animal's condition and needs of a specific balanced ration. As with everything new, mistakes are made and sometimes these mistakes cause trouble, and the trouble is only recognized after the damage has been done. In some cases, feeders disregarded entirely the warning that dry yeast was not to be fed alone, but mixed with cheaper feeds; that is to say, with feeds of lesser nutritive value, so as to properly balance the feeding ration. Some of you gentlemen may be fully acquainted with the theory of animal feeding, and you probably have even had practice, so that you can fully grasp the importance of this so-called "ration balance." Protein-Carbohydrate. This principle has been experienced in the use of all concentrated foods, such as, for instance, cornmeal, cotton seed, linseed, etc.; and an examination of the food value of dried yeast makes it apparent that only small quantities of it added to inferior bulk

food brings its feed cost within reach of general consumption.

Dry yeast is practically all food. It contains no waste, tests having proven that over 90 per cent is assimilated in the animal body, also assisting the assimilation of inferior foods.

Various analyses, which we had made at different institutions and by chemists, have resulted in about the following averages:

	Per cent
Water	8
Ash	7
Fat	3.5
Fibre	1.5
Protein	54
Carbohydrates or nitrogen-free extracts	26

Analyses further prove that dried yeast contains a not inconsiderable amount of phosphoric acid, also large quantities of nuclein, lecithin and so-called "vitamines"—substances which are recognized as most essential to life, and of characteristics which contribute to good health and growth. It would carry us too far to go into details of these attributes, and I confine myself to the statement based on experience that animals fed with dry yeast in connection with their other bulk food, proved free from ordinary diseases and recovered quickly from such diseases, even from foot and mouth disease.

I am able to state that the United States Agricultural Department at Washington is now and has been for the last seven or eight months carrying on rather extensive experiments with dry yeasts which we furnished to the Department at their Experi-

mental Station in Maryland. You may possibly know that such tests and experiments take months, and sometimes years, for completion, and although I have urged the department to give me some indications of results, these have not yet been published; but I am assured by the director, that they hope to publish their findings within a short time.

Other agricultural stations in different states are also interested, but I am not yet able to give findings from any of these at the present time. The great trouble in these cases seems to be that the appropriations, either state or federal, are very meager, and the directors do not feel inclined to divert money from the usual purposes, to something new.

In Europe, where all these experiments and demonstrations are under absolute governmental control and paid for by the government in a liberal and far-seeing fashion, they are much further than we are on this side; hence, we have reports from there, which have advanced not only the value of brewers' dry yeast as an animal food, but also in therapeutic uses and in medicine. I refer to the reports of the Berlin Institute for Fermentation; also to the works written on this subject by Vet. Dr. Steffen in Kiel; Vet. Dr. Paechtner; Vet. Dr. Baudrexel; Vet. Dr. Hoffmann; Vet. Dr. W. Voeltz, and others. When we read these reports of practical experiments, tests and observations it must occur to us how much further and with how much more detail they treat questions of this kind on the other side than they do here, where, in spite of money

spent, comparatively small results are obtainable. I was struck with the fact particularly during my visits to various agricultural institutions and stations in the United States. It may be that the necessity for economies has not yet arrived in this country, but I am sure you will all agree that a nickel saved is worth a great deal more than its face value in times of stress.

The tests and experiments referred to are made with feeding Horses, Cows, Calves, Sheep, Hogs and Poultry.

In all these experiments large increases were shown in weight, growth, quality of meat, yield of milk or eggs. It was shown that the yields were very much larger than the cost of foods consumed *with* Dry Yeast.

Aside from the animal food possibilities, I believe that in the medicinal field a great vista is opened for dry yeast. I have induced a large number of physicians to prescribe dry yeast, which I prepared experimentally, and I have to report but the very best results in many ailments resulting from malnutrition or wasting conditions. You know well enough that physicians, as a rule, are sceptical because they are bombarded every day with nostrums and patent remedies of all kinds, and it takes a great deal of persuasion to have them adopt a new thing; but I have succeeded in getting very favorable opinions from eminent men, and dry yeast is being used today by many patients, with absolutely good results. How I came to recognize dry yeast in a medicinal way is very simple indeed. I read,

a couple of years ago, a book mentioning brewers' yeast as indicated in the treatment of many ailments, and when I learned besides this, that its composition fitted it eminently as a dietary food in wasting diseases, I consulted several specialists, and they indorsed my opinion; subsequently, I found, after a month's use, that my belief was fully justified. Please understand that I am not making any extravagant claims for dry yeast as a "cure-all" or even as a cure for certain ailments; I do make the claim that it is a help in nutrition, and I should be only too happy if my endeavors will bring relief in some failing.

The field of employment in a medicinal way is very large indeed, and I believe that we have practically only pricked the surface, hoping that some of you gentlemen will continue where I have left off, and exploit the subject to your financial benefit. You might ask why we do not engage in this pursuit ourselves. The answer is very simple. We are engaged in mechanical and technical work, all our means, energies and thoughts are engaged in that line; in other words, we have no business to take up part of the brewers' business. He understands the handling of the yeast; he has the facilities for its handling, the means for its proper preparation and treatment in a sterile way, and he is in a better position to exploit the product from other breweries than we are.

Aside from yeast, there is available in every brewery a large quantity of pure albumen, resulting from the precipitation or settling of the so-called

"trub." We estimate that this "trub" represents more than one pound wet per barrel, and when collected similarly to the methods emeployed for collecting yeast, it will yield, when dried, a large quantity of pure dry albumen, which finds a ready sale in the market, or it can be mixed with the yeast.

A further saving can be had from the yeast drier in settling out the precipitate from the liquor of brewers' grains presses where such are installed. It may be new to you that the grains liquor pressed out of the brewers' grains in the grain presses contains more than 5 per cent of solids, and that these solids average about:

40% of protein,
37½% of carbohydrates,
7% of fat, and
5% of ash.

A test was made at the Farmers' Feed Company in Toronto, Ontario, some time ago, and we allowed to precipitate appromixately two tons of grains liquor, and obtained a little more than 200 pounds of dry residue. When it is considered that this particular grains press yields about 6,000 gallons of liquor per day of 10 hours, you can see that about 3,000 lbs. of dry good feeding material has gone to waste for years past.

We are naturally on a constant watch for new uses, and we have found lately that dry yeast is used as a clarifying material in chemical industries. Just how it is applied, we have not been able to learn, but we are informed that its use is on the increase.

We have, furthermore, a few months ago,

received an order from a dye-stuff concern in Boston for 10 tons of dried yeast. The concern sent us a sample of some German yeast, and asked us if we could furnish it, and at what price. Our experimental material being far superior in appearance to theirs, we concluded that we should not give it away, but offhand asked the price of 10c a lb., really never expecting that an order would be placed. Behold, to our surprise, when about a week later, a definite order was placed with us for the above quantity at 10c a lb. Not being able, with our small experimental machine, to turn out anything like this quantity, we turned the order over to a New York State brewery, who have one of our yeast driers in operation, and we know that they have executed this concern's order, and no doubt made a handsome profit.

It would be useless for us to seek new fields, like for instance the above, for the simple reason that we cannot supply the material. In a brewery the yeast costs nothing, the collection costs no more than the washing out does now, and the only expense the brewery is under, is to install an outfit, supply steam to it, and a little power. I have heard it said several times that casual attempts at yeast drying were made in Chicago or other places, and that these attempts were not successful. I know about these trials and know also the reason why they were not successful. The driers employed by two experimenters were absolutely impossible, and the material produced was of an appearance and consistency which made its use also impossible.

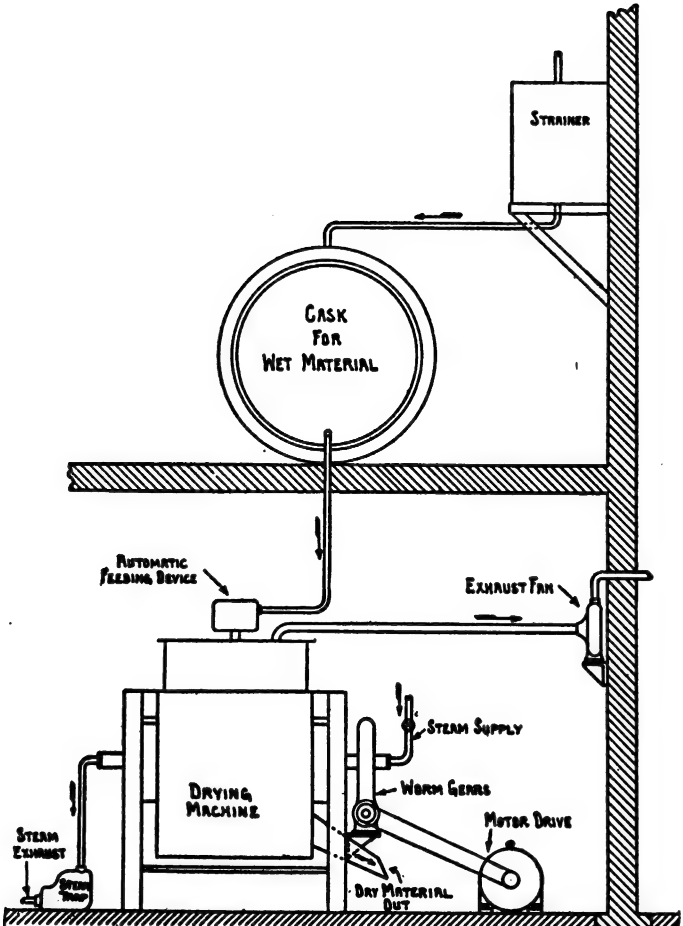
I do not wish, except in passing, to touch on the possibility of utilization of dry yeast as a human food, because there is no likelihood that in this country the need for it will ever arise, but I have true information that in Europe dry yeast has been made a human food by stress of necessity, and chemists have succeeded in making it absolutely palatable and acceptable to the people. For such purposes, it is necessary, of course, to remove the bitter taste from the yeast, and there are easy ways and means to accomplish this, but I repeat that these manipulations require sanitary localities and facilities which exist, to great advantage, besides refrigeration, in a brewery.

We have come to the conclusion that a duplex machine, that is to say two machines of a stated capacity coupled together with one drive and one exhaust, but with independent feeding arrangements, will be more practical:

First, on account of the bulk of a larger machine and increased building cost.

Secondly, owing to the possibility of uncoupling one unit from the other and running only one in times when yeast is not as plentiful as in the high season.

Another word as to capacities and production: Our experience has shown that a brewery of say 100,000 bbls. yearly output can produce, including the albumen, over 1 lb. of dry material per barrel of beer, which would yield, in round figures, say 100,000 lbs. of dry material. Our experience has



DIAGRAMMATIC DESIGN OF A
WITTEMANN COMPANY
"YEAST DRYING APPARATUS"

shown that the total expense of producing this quantity in a brewery is not over 1c a lb., figuring coal for heating and power, labor and the usual 10 per cent per year for amortization. Assuming that the average market price for brewers' dry yeast in a short time will be 8c per lb. at the place of production, it would seem that an installation would very soon pay for itself.

A short description of my suggestions for arrangements for collecting of the yeast and albumen in a brewery may now be in order.

A brank fitted with an outlet bushing for hose connection at the lower side can be moved from cask to cask. A hose is connected to this brank, and the yeast flows by gravity to a collecting vat on the floor below. Naturally, if this arrangement is not possible, a portable small centrifugal pump either hand operated or electrically driven from the electric light sockets, can be moved, together with this collecting brank. From the collecting vat, a 2-inch connection is made to the automatic feed boy of the yeast drier, which preferably should stand again on a lower floor, or in a convenient locality outside of the brewery. It also would be convenient to have sufficient space beneath the yeast drying machine to build a small receiving bin for the dry yeast—large enough to hold one day's run. This yeast bin to have a hopper bottom, which makes it very convenient for bagging off the material, which can be done in about one hour's time. This arrangement would save the attendance of one man during

that run for the removal of the full, and the placing of the empty receptacles.

Cleansing of the entire apparatus, of course, with hot water after completion of a run, is necessary, and where a run should be continuous, a thorough cleansing should any way be done about every other day, or at least once a week. R. A. W.

Condimental or Stock Foods.

Proprietary articles styled "stock foods," "seed meals," "condition powders," etc., costing from 10 to 30 cents or more per pound are extensively advertised and sold to American farmers. Woll, of the Wisconsin Station, after ascertaining the amount of stock foods sold in three counties in Wisconsin, estimates that the farmers of the state pay annually about $300,000 for 1500 tons of such material. Michel and Buckman, of the Iowa Station, estimate that Iowa farmers paid $190,000 for stock foods in 1904. The better class of their foods have for their basis such substances as linseed meal or wheat middlings, while the cheaper ones contain ground screenings, low grade milling offal, etc.

Brewery Feeds. These feeds might be expected to be of a rather uniform composition, but the analyses made, show that they are subject to as great variations in valuable constituents as are other feeds. While the quality of the barley and other grains used in the malting process is doubtless an important factor in determining the composition of these by-products, differences in the manufacturing proc-

esses, especially whether refuse materials like barley hulls, screenings, weed seeds, etc., are added to the dried grains or sprouts, largely determine the quality of the feeds. The relatively low price at which both these feeds may generally be obtained, renders them of special value to feeders. They furnish a cheap source of protein and are valuable for supplementing farm-grown grains, especially in the feeding of dairy cows.

Mixed Dairy Feeds. Among the feeds included in this class are some possessing considerable merit and others that cannot be considered desirable feeds from the buyer's or feeder's standpoint. While most of the feeds contain fair amounts of valuable food components and do not contain excessive percentages of fiber, it is evident that the prices at which they are sold often render them expensive feeds in comparison with standard feeding stuffs on our market. The per cent of fiber present in the feeds or guaranteed by the manufacturer is, in general, a good indication of their value, since low-grade refuse materials are always high in fiber, and large admixtures of such materials render the mixed feeds high in this component.

The number of molasses or so-called sugar feeds on the market in this state has been gradually increasing of late years. When manufactured from standard feeding stuffs and sold at a reasonable price these are well worthy of a trial, but molasses may be used as a cover for poor or largely worthless materials, and buyers should make careful exami-

nation of these feeds before investing their money in them. Many contain large quantities of screenings and weed seeds, which may be the cause of fouling the land with weeds when fed to stock, unless the screenings are finely ground or the vitality of the seed destroyed in the manufacturing process. Alfalfa meal contains less protein and fat and nearly three times as much fiber as wheat bran. The amounts of digestible components present in these feeds show that wheat bran is the more valuable feed of the two. The quality of the hay used in the manufacture of alfalfa meal can only be determined by a chemical or microscopical analysis, and the buyer has no assurance that it was made from even a fair grade of hay, while in the case of wheat bran a mere inspection will reveal its quality, at least as to the presence of foreign materials. Unless it is sold at an appreciably lower price than wheat bran, the purchase of alfalfa meal cannot, therefore, be recommended. Mixtures of alfalfa and standard feeding stuffs like corn, molasses, or various by-products, are of considerable merit, provided a good quality of alfalfa hay was used in their manufacture.

Calf Feeds. These feeds are generally mixtures of ground farm grains, mill feeds, and flax seed or oil meal, with small amounts of materials like molasses, sugar or condiments, which are added to further increase their palatability. Their cost is generally out of proportion to their actual feeding value, as compared with that of standard feeds on our mar-

kets, but they make valuable substitutes for or additions to skim milk in rearing calves.

Horse and Swine Feeds. These feeds are of similar origin as the mixed dairy feeds. They are only to be recommended when put up by reliable manufacturers who value their business reputation and aim to furnish their customers with the best feed mixtures possible at the prices asked. The cost of these feeds is generally as high as that of the standard ground feed or grains.

Industrial By-products. The more important industries in which by-products suitable for the nutrition of farm-stock are obtained are malting, brewing, distilling, the manufacture of starch and sugar. Here belong also the by-products of the flour mills and oil mills.

Malt Sprouts. Malt sprouts which have been separated from the dried malt grains are rather low in carbohydrates and fat, but carry about 20 per cent of digestible crude protein, one-half or more consists of amides. Though rich in crude protein they are not relished by stock, and should be given in limited quantity in combination with other concentrates. The Massachusetts (Hatch) Station found that cows would not eat over 2 or 3 lbs. malt sprouts daily. They absorb much water and should be soaked several hours before feeding.

Screenings. In cleaning and grading wheat at the elevators and mills, great quantities of screenings remain, consisting of broken and shrunken wheat

kernels having a high feeding value, and also weed seeds, many of which have value, while others are of little worth, and a few actually poisonous. Screenings have their place and use, though, on account of their variable character, little of definite nature can be said concerning them. Along with molasses and the by-products of the distilleries, breweries, flour mills, oatmeal factories, etc., they are now largely absorbed in the manufacture of proprietary feeding stuffs.

Dried Brewers' Grains. By removing practically all of the moisture from wet grains by means of the drying process, a concentrated product known as "dried brewers' grains" is obtained, which is no more perishable than wheat bran. Dried brewers' grains are rich in both crude protein and fat, with considerable fiber due to the barley hulls. They are low in carbohydrates, which in these grains are largely pentosans. Dried brewers' grains are an excellent concentrate for dairy cows, ranking with bran and oil meal in palatability and general good effects. The Massachusetts (Hatch) Station found them cheaper than oats for horses and as satisfactory, especially for those at hard work and needing extra crude protein. From one-third to one-half of the concentrates in the ration for horses may consist of dried brewers' grains, and the remainder of either corn or oats. Being high in fiber, dried brewers' grains are not satisfactory for pigs.

Dried Distillers' Grains. Like oil meals, both gluten feeds and distillers' grains are valuable feeds

for farm stock, especially dairy cattle, and are uniformly of good quality and free from foreign admixtures. Dried distillers' grains may be considered of about the same feeding value as oil meal. At present market prices the feeds of this class are generally cheaper than oil meal, since for the same amount of money they furnish larger amounts of digestible components than does this feed. For feeding young stock, oil meal may, however, be preferred even at present prices, on account of its mild laxative and other specific properties.

Spent Hops. Spent hops on account of their composition, which corresponds to that of red clover or hay of medium quality, have been recommended for fodder. Kellner, who made extensive nutrition experiments, found that in consequence of the low digestibility and the reluctance with which cattle eat spent hops this substance cannot find an extensive use as a fodder. All additions of hops to the daily food are not rejected inasmuch as the appetite of the animal is stimulated thereby. Pott proposed to add spent hops to distillers' and brewers' grains, and this suggestion appears worthy of attention, since it is likely that the tannin is possessed of preservative action and would exert a desirable influence upon preservation of the material.

Molasses and Sugar Feeds. Ordinary household sugar is prepared from sugar cane and sugar beet. In both cases the material is reduced to pulp, and the sugar extracted in aqueous solution. This solution is concentrated by evaporation in vacuum

pans and the sugar is crystallized out. A considerable amount of sugar, however, remains in an uncrystallizable condition and forms the black viscous liquid called molasses or treacle. The uncrystallizable sugar has the same nutritive value as that which crystallizes, and it forms about 60 per cent of the total residue, treacle.

Cane sugar molasses is used as food for human beings; that obtained from beet is more impure, has a strong bitter taste, and is not fit for this purpose. It is, however, used in large and increasing quantities for cattle feeding. Apart from water, the impurities consist mainly of amides and potash salts. As both of these are liable to interfere with the processes of digestion and derange the health of the animals, treacle can only be given in limited quantities. Though of little or no nutritive value, the amides and potash salts tend to enrich the manure. This fact should not be overlooked, as it might be, for molasses is rightly regarded as a purely carbohydrate food.

The best way to use this substance is to dilute it with hot water and mix the solution with other foods, e. g. hay or straw, maize, etc. The sweet flavor is greatly relished by the cattle, and treacle may be used as a condiment for food that is otherwise not very appetizing. It should never be used, however, to induce cattle to consume food that has become mouldy, decayed, or otherwise unfit for use.

Materials of this kind can now be obtained ready prepared. They are called molasses meals, sugar

feeds, or by some fancy name. The condition in which they are sold is usually that of a slightly moist but friable meal or powder, which is more convenient to handle than the viscous liquid. The absorbent material most commonly used is peat. This substance is not only of no nutritive value in itself, but probably lowers that of the molasses mixed with it. Chaff, husks, and similar substances are sometimes used instead, and such samples are generally guaranteed to contain no peat. The nutritive value of these substances is very little, if at all, superior to that of peat, and they are very liable to be infected with moulds or other deleterious fungi. The amount of absorbent material required to produce a fairly dry meal is, however, relatively small, and, as the products are not used in large quantities at a time, it probably does little harm. These meals usually contain from 40 to 50 per cent of sugar, and should be valued solely according to the amount of that constituent.

Oil Meal and Cotton Seed Meal. Oil meal and cotton seed meal are two of our most valuable feeds, especially for feeding dairy cows, on account of the large amount of protein which they contain. At the present high feed prices both digestible protein and total digestible matter are supplied at a lower cost in this class of feeds than in cereals and mill feeds. When the manurial values of feeds are considered, oil meals must also be placed at the head of the list of desirable feeds for the farmers to buy. Both on account of its higher manurial value and

the lower price at which it is sold, cotton seed meal is to be preferred to oil meal (linseed meal) in feeding dairy cows. It is by far the cheapest high-protein food on our market today.

Gluten Feeds. Gluten feeds proper represented are of two classes, as indicated by per cent of ash which they contain. When the water used for softening the corn (steep-water) is evaporated and the solids added to the gluten feed, as is done by some manufacturers, the ash content of the feed is considerably increased and the protein is also likely to be higher, but the latter increase comes from the addition of soluble nitrogenous, largely non-albuminoid compounds; hence the protein in such gluten feeds may be of less value than would appear from the analyses when the total crude protein only is determined. The wisdom of adding the solids contained in the steep-water has lately been questioned, and the claim is made that the gluten feed thus manufactured is a less desirable feed, as regards flavor and keeping quality, than that containing only corn bran, gluten, and undissolved starch (endosperm).

Wheat Bran. The composition of the wheat determines to a large extent the composition of the by-products, spring wheat being, as a rule, lower in starch and higher in protein than winter wheat. The same relation holds good, generally speaking, with the offal feeds. The chemical composition of the by-products is not, however, beyond the control of the miller, as is sometimes stated, for the variations in the manufacturing processes are more im-

portant than those in the chemical composition of the wheat itself. If this were not so, all bran from mills using wheat of similar origin would have the same composition, which is not the case. By studying the results of the analyses of bran and other mill feeds, a miller may determine with considerable certainty the guarantees for protein, fat and fiber in his feeds which he may safely adopt in his particular case.

Wheat Middlings. There are two grades of middlings on the market, so-called standard middlings (or shorts), and flour or white middlings. The latter feed contains more red dog flour than the former, and is generally higher in protein, fat, nitrogen-free extract (starch), and lower in fiber and ash than standard wheat middlings.

The common adulteration of middlings is the admixture of fine-ground screenings, which is practiced by a few mills.

Hominy Feeds. Hominy feeds are the residue obtained in the manufacture of hominy from Indian corn. These feeds, like those of the preceding group, are free from adulterations and are palatable and highly digestible. Their relatively low protein contents and high contents of starch and other non-nitrogenous constituents place them in a class with corn and other cereals, and they may be considered valuable substitutes for these feeds.

Flour Mill Feeds. The danger of fouling the land with noxious weeds by feeding whole screenings, or mill feeds adulterated with screenings, to farm

animals has often been referred to. The practice of adulterating mill feeds with screenings has now fortunately been generally abandoned by the millers. If the screenings are finely ground, as they can be with modern machinery, the objection to their use on account of the danger of introducing weeds on the land is removed, but also in this case the admixture must under our state law be specifically stated on the sacks in which the feeds are sold, or on the printed tags attached to the sacks.

Other Wheat Feeds. Under this head are considered germ middlings composed largely of the wheat germ, with adhering floury portion and mixed feed, a mixture of bran and middlings.

Rye, Barley, and Buckwheat Feeds. Of the mill feeds other than the by-products in the manufacture of wheat flour, rye feed is the most important in this state, with buckwheat feed second. Only one grade of by-products is generally obtained in making rye flour, which is sold by different millers as rye feed or rye middlings.

Buckwheat feed is composed of varying proportions of buckwheat hulls and middlings, and is generally sold locally at the mills. There is considerable confusion in the terminology of different buckwheat by-products. As used in this part of the country, at least, buckwheat feed means the entire offal in the manufacture of buckwheat flour and will contain one-half to one-third of hulls, the balance being made up of the heavy floury portion of the

buckwheat grain immediately inside of the hulls, known as middlings or shorts. Some of the buckwheat feed sold, however, comes close to being pure hulls (or buckwheat bran, as it is sometimes called with a more euphonious name). The middlings and hulls are sometimes sold separately, but buckwheat middlings which are a very valuable and rich feed, are rarely seen on the market. Buckwheat feed composed of about one-half hulls will contain about 15.7 per cent protein and 24 per cent fiber, and one containing one-third middlings and two-thirds hulls, about 12 per cent protein and 30 per cent fiber. A study of the digestible components furnished by this feed and by wheat bran would lead to the conclusion that a good quality of buckwheat feed (containing not much over one-half hulls, by weight) is worth about 20 per cent less than wheat bran; it can generally be obtained at a lower price than this at local mills.

The following table giving the analysis of various malt house and brewery by-products which can be used as feeding stuffs is based on actual analysis made by the author and compiled by him. X is a prepared feed, which at the time the analyses were made commanded a market value of about $30.00 per ton. A food very similar if not actually identical could be compounded from the various raw materials given in the table at a cost of less than $13.00 per ton. Every one of the brewery and malt house by-products can be completely utilized in the preparation of a compound feed, selling at a very high market price.

Analysis of Malt-House and Brewery By-Products Used as Feeding Stuffs.

Name of Feed.	Water.	Ash.	Crude Protein	Carbohydrates. Fiber.	N.-free extract.	Fat.
	%	%	%	%	%	%
Chaff	7.04	5.7	7.0	20.5	57.28	2.52
Seed Screenings	8.4	6.0	15.05	11.0	50.57	8.08
Barley Screenings	10.9	3.6	11.70	9.48	61.53	2.79
Caramel Malt } Sprouts	2.16	6.5	25.00	14.85	48.25	3.24
Rye Sprouts	3.87	6.2	28.40	6.19	53.02	2.32
Barley Sprouts	3.78	6.0	24.15	15.0	49.68	1.39
Sprout Mixture	4.35	6.4	26.90	11.5	50.85	1.85
Dry Brewers' grains	1.15	4.0	29.20	15.0	43.85	6.80
Skimmings	6.9	3.5	11.75	12.70	62.49	3.02
X Prepared Feed	5.0	4.6	22.87	5.28	60.32	1.93

A book by Kellner on the Scientific Feeding of Animals contains very comprehensive tables showing the composition, digestibility and energy values of most of the foods used on the farm, and ration tables for the dieting of farm animals compiled from the result of scientific investigation.

A useful table compiled by A. Smetham showing the composition of a large range of feeding stuffs met with in commerce, including many materials not commonly offered as such to the farmers, but in extensive use for the manufacture of compound food, may be found in a paper reprinted from the "Journal of the Royal Lancashire Agricultural Society" for 1909 and published by Mawdsley & Son, of Liverpool, England, under the title of "Some New Feeding Stuffs and Their Relative Value as Cattle Food."

IX. Dairy Industry.

By Carl Nielsen, Ph. C., Chicago, Ill.

THE dairy industry is a very desirable field for the trained fermentologist. As such the brewer should not let any opportunity go by to enter this line of business, and the student of fermentology should make himself familiar with the knowledge required. It offers ample opportunity to the man who is willing to study, and able to work toward improvement of the great variety of dairy products; and there are many possibilities for creating new products within the scope of this industry.

There is moreover reason to believe that a brewery could be changed into a plant manufacturing certain dairy products, without too high initial expenses. Such a change, if handled right, would undoubtedly be of benefit to the concerned, for there is, and always will be, a demand for good, clean, and wholesome dairy products.

The milk is at the present time utilized in many forms, but even the most common of these lack uniformity. Very seldom, if ever, is such painstaking exactitude applied in the manufacture of dairy products as that which the brewer must observe to obtain a uniform beer. And although most of the dairy products are products of fermentation, where the quality depends upon the work of certain definite organisms, the pure culture system, used for years in the breweries, is not in general use in this

industry. There may be more difficulties to overcome before uniformity in production can be reached, because of the nature of the raw product and the great variety of organisms involved in the process of fermentation, but it is only a matter of time before this can be accomplished, and the work is therefore made more interesting to the student as well as to the technical expert.

Large quantities of whey and buttermilk, by-products from butter and cheese factories, are sold for almost nothing to the farmers, for hog feed, or wasted through the sewer. Both articles contain valuable nutritious substances, and can be made into desirable, palatable food products by proper treatment.

Casein which represents the bulk of nitrogenous food in milk is manufactured in large quantities in dry powder form, for technical uses. But although it enters into a number of general foods as a constituent of the milk, and is the main ingredient in the milkcurd used for making cheese, few attempts have been made to utilize the pure casein in a digestible form for food, and none of them have been very successful.

The Department of Agriculture of the United States Government is doing splendid work through the Bureau of Animal Industry, constantly employing scientists and technical experts to aid and assist the dairymen. Anyone entering this field should consult the Government as to local business conditions, buildings and machinery needed, the demand for certain products according to the locality, etc., etc. He

should also make himself familiar with the latest works published in the bulletins and circulars of the Department of Agriculture, Bureau of Animal Industry.

There is moreover an abundance of literature dealing with dairying, from all parts of the world. Some of the greatest scientists, Pasteur, Freudenreich, Lafar and others, have contributed to our present knowledge of milk and its products, but there is need of scientifically and technically trained men to apply theories to practice.

Brewing and dairying are closely related industries. Both deal with foods made pleasant to the taste. Both require knowledge of fermentation, utilizing the friends and fighting the foes among the micro-organisms. For these reasons the brewer who enters this field would not feel a stranger, but rather a brother able to do his share of the work.

The object of this short contribution is to offer to the brewer and student of fermentology introductory information on the subject, and a list of references to the literature.

Whole Milk.

The composition of cows milk varies with the season, the different breeds of cows and their food, the intervals between milking, and the period of lactation.

The average composition may be said to be as follows:

	Per cent
Water	87.5
Fat	3.5
Casein	3.0
Albumen	0.65
Lactose	4.6
Ash	0.75

The mineral matter determined by ash analysis (Soldner) consists of:

	Per cent
Sodium chloride	10.62
Potass. chloride	9.16
Monotopass. phosphate	12.77
Dipotass. phosphate	9.22
Potass. citrate	5.47
Dimagnesium citrate	3.71
Magnesium citrate	4.05
Dicalcium phosphate	7.42
Tricalcium phosphate	8.90
Calcium citrate	23.55
Calcium oxide in combination with casein	5.13

Milk is naturally a favorable medium for microorganisms. Some of the bacteria that occur in milk belong to the pathogenic group, and they would, if present, endanger the health of the consumer seriously. Several diseases have been traced to contaminated milk as their source, namely: scarlet fever, typhoid fever, diphtheria, tuberculosis, and throat infections. But by far the highest percentage of organisms able to grow in milk is of nonpathogenic character. A number of the most frequently occurring have been investigated and their behavior is known; but there are still many species of which we know nothing but that they spoil the milk. The following groups of organisms may be said to be present always in raw milk: lactic acid producing bacteria, peptonizing bacteria (mostly

spore-bearers), lactose fermenting yeasts, and molds. The lactic acid bacteria produce lactic acid from lactose, sometimes to the extent of 3½ to 4 per cent. The peptonizing bacteria consume the casein, the yeasts ferment the lactose under production of alcohol and carbonic acid, while the molds decompose the albumin under production of ammonia.

The milk becomes contaminated as soon as it leaves the udder, and the number of organisms increases rapidly even at a relatively low temperature. As the lactic acid bacteria are the predominating, the acidity of the milk increases until it reaches the degree by which it curdles, that is, casein and albumin are precipitated.

Conn has given an interesting illustration of this increase in the number of bacteria, as shown in the following table:

Number of bacteria per Cc. in milk kept at different temperatures.

Number at outset	In 12 hrs. at 50° F.	In 12 hrs. at 70° F.	In 50 hrs. at 50° F.	In 50 hrs. or at time of curdling at 70° F.	No. of hrs. to curdle at 50° F.	No. of hrs. to curdle at 70° F.
46,000	39,000	249,500	1,500,000	542,000,000	190	56
47,000	44,800	360,000	127,500	792,000,000	289	36
50,000	35,000	800,000	160,000	2,560,000,000	172	42

It is therefore essential that the milk be kept at as low temperature as possible until it can be pasteurized. The temperature of pasteurization for whole milk is approximately 176° F., followed by as rapid cooling as possible. (For details of process and machinery consult the bibliography.)

The pasteurization destroys the disease germs,

but a number of others survive, particularly spore-bearers and molds, and also certain species of lactic acid bacteria. This accounts for the fact that even pasteurized milk curdles, or spoils, when kept too long before consumption.

The milk may, of course, be made germ free by proper sterilization, and this is now and then practiced on a large scale. But the pasteurization has great advantages over sterilization, in that it destroys the disease germs as efficiently as sterilization, prolongs the keeping quality of milk sufficiently, leaves the fat and lactalbumin unchanged, does not affect the natural flavor, and offers a product which is more easily digested than the sterilized milk.

All these organisms, with the exception of the disease germs, are not harmful to the consumer, and some of them influence the quality of the milk only when present in large amounts. But certain species produce decided changes in the consistency, appearance and taste of the milk, and as some of these are frequently met with in carelessly handled milk, we shall mention them briefly.

Milk of soapy taste and strong lather is due mainly to the presence of Bac. lactis saponacei, a short rod, which forms slimy colonies on nutrient gelatin, turning to a rusty yellow on the surface.

Milk may acquire a bitter taste, due to certain foodstuffs fed to the cows; but often the bitterness is produced by certain species of lactic acid bacteria and torulae.

Ropy, or slimy milk is due to various species of

lactic acid bacteria and peptonizing bacteria, particularly Bac. lactic viscosus, and Micrococcus Freudenreich. The latter liquifies gelatin.

Blue milk is most frequently, although not exclusively, caused by Bac. cyanogenus, a short, motile rod, which digests the lactalbumin under production of blue coloring matter.

Red milk, due to Bac. lactis erythrogenus, or Sarcina rosae; and yellow milk, due to Bac. synxanthum, are of less frequent occurrence.

From the above short description of the general bacteriology of milk, it is evident that strict cleanliness in the handling of milk under the supervision of trained fermentologists, is indispensable, from the time the milk leaves the udder to the time it arrives in the hands of the consumer.

Cream

For details as to the commercial features and the technic of preparation of cream, we refer to the Department of Agriculture, Bureau of Animal Industry. The machinery for separating cream from milk can be purchased on the market.

Koenig gives the following composition of cream:

	Per cent
Water	65.51
Solids	34.49
Casein and albumin	3.61
Fat	26.75
Lactose	3.52
Salts	.60

Other authors have found the normal fat content in cream to be from 45 to 50 per cent. The

fat content varies, of course, with the method of separation.

The fat in milk and cream is present as microscopic globules, varying in size from 0.0016 to 0.01 micro-millimeter. Rothschild found that a drop of milk of the size of a pin's head contained approximately 1,500,000 separate fat globules. In other words, milk and cream are emulsions, in which the fat is presented in an easily digested form.

In separating cream from milk, about 90 per cent of the bacteria are carried over in the cream, which therefore contains an enormous quantity. Upon standing, the lactic acid bacteria become predominant.

Pasteurization (165-175° F.) is the best method for preserving cream. Sterilization changes it and causes the fat globules to melt and coalesce.

The utilization of cream for butter manufacturing is taken up in the following chapter.

Butter.

This well known food is a product of fermentation, made from cream. The process is briefly as follows: The cream is ripened, that is, lactic acid bacteria are allowed to act on it until it has the desired consistency, acidity, aroma, and flavor. The sour cream is then churned, a process of stirring whereby the fat globules coalesce and separate in small lumps. These are carefully washed, so as to free them from adherent buttermilk, and are then worked together by kneading and constant washing under the addition of salt.

The chemical composition of butter is as follows:

	Per cent
Butter fat	83.15
Water (from 10 to 16 per cent)	13.75
Albumin	1.00
Lactose	0.2
Milk ash	0.15
Sodium chloride	1.75 or more

Stearin, palmitin, olein, and traces of myristin and butin, 91.5 per cent.

The composition of butter fat is approximately as follows (Duclaux):

	Per cent
Stearin, palmitin, olein, and traces of butin	91.5
Butyrin	4.2
Capronin	2.5
Caprylin, caprinin, and traces of laurin	1.8

The butters on the market vary greatly in consistency, aroma and flavor, and it is these three factors, especially the two latter, which determine the market price. The aroma and flavor are not due to the butter fat itself, but are results of the ripening process, or, more correctly, the fermentation.

Microscopical examination of butter reveals a great number of minute globules in a uniform mass of butter fat. These globules are remainders from the buttermilk and contain the aromatic substances produced by the bacteria in the cream. Thus it is to these globules that the butter owes its aroma and flavor, and it is therefore the fermentation of the cream which first of all determines the quality

of butter. Whatever method is used in "ripening," it is essential that the cream be of good quality. The fermentation is brought about by the addition of a "starter," a culture of lactic acid bacteria, propagated in cream or milk.

The greatest percentage of butter in this country is made with a "natural starter," that is, a non-pure culture of lactic acid bacteria. Such a starter is chosen from the various batches of fermented cream in the creamery as the one which has the most desirable aroma, flavor and consistency, and is kept up by daily transferring into fresh cream. This natural starter contains mainly lactic acid bacteria, and may at times be an almost pure culture of one definite species. But it may also contain other organisms, and these latter may at times produce very disappointing results, sometimes spoiling the entire yield of butter. It is true that the lactic acid bacteria, when present in the majority, will outgrow the other species under favorable conditions, but a natural starter should not be depended upon any more than a contaminated yeast for beer.

The cream as obtained in the creameries contains more or less 100,000,000 bacteria per Cc. The majority of these may be lactic acid bacteria, but sometimes these latter have been found to be present only to the extent of 10 to 20 per cent of the total.

In this country the cream is mostly used for butter manufacture without previous pasteurization. Although a culture of a vigorous strain of lactic

acid bacteria added to such cream usually causes rapid destruction of the undesirable micro-organisms, by predominating growth, this process notwithstanding means taking chances. A non-pasteurized cream for butter should not be depended upon any more than a contaminated wort for brewing.

Virtually all of the butter in Denmark is made from pasteurized cream, and the "starters" used are pure cultures of lactic acid bacteria. Pasteurization is, in that country, required by law. If butter of its fame can be made thus in Denmark on a commercial basis, it can be so manufactured in this country.* Moreover, the better the product, the higher the market price; and the pure culture process is bound to yield a uniform and better product. Pure culture butters have obtained a price of ½ to 2 cents a pound more than the ordinary butter.

We recommend that the following points be observed in making butter:

1. Pasteurize six quarts of cream, at about 165° F. When cool, add a pure culture of an organism of the required properties (see later), and place at about 70° F. for a couple of days.

2. Add this subculture to about 25 gallons of pasteurized cream. Allow to develop and use this as a starter.

3. Add one gallon of starter to each 25 gallons of cream in the main vats. To obtain best and uni-

*Pasteurization as Applied to Butter-Making. Wisconsin Agricultural Experiment Station, Bull. 69, 1898.

form results, the cream should be previously pasteurized. In creameries where there are no facilities for doing this, or where it is not desired because of the added expense, great care should be taken in using good and clean cream.

4. Allow the whole to ferment at a proper temperature. This temperature varies according to the character of the organism used. The lower the temperature, the better the aroma and flavor of the finished product.

The cream is then ready for churning. Information as to this and other mechanical processes of butter-making may be obtained from the dairy machinery dealers, or from the United States Department of Agriculture, Bureau of Animal Industry.

The freshly prepared butter may still contain about 30,000,000 to 50,000,000 bacteria per gram. As butter is an unfavorable medium for bacteria, these quickly succumb, and after a few days the butter contains only a fraction of the original number. This decline continues further, and some butters have been found to be almost free from organisms.

The culture of lactic acid bacteria used as a "starter" should answer the following requirements:

1. It should ferment the cream to the desired degree with relative rapidity at a low temperature.

2. It should produce a fermented cream of a uniform consistency and a slightly sour taste and odor.

3. It should give to the finished butter an agreeable aroma and flavor.

Pure cultures of this nature can be purchased from dairy laboratories. The best two known are Hansen's Dairy Starter, a Bact. lactis acidi of the diplo-streptococcus form; and Conn's bacillus No. 41. The first is said to give more aroma than flavor; the latter, more flavor than aroma.

The pure culture method, however, is not used nearly as extensively as it should be in this country, presumably because it is too difficult and cumbersome for the untrained help. To the trained brewer or fermentologist the culture work would be a pleasant duty, with gratifying results to him and the industry alike.

Ice Cream.

The dairy products may be divided into two groups, according to their nature, to wit: the fermented and the nonfermented. The most important products belonging to the latter group are Ice Cream, Casein, Condensed or Dessicated Milk and Milksugar. Of these four the two first require the least expenditure, and are comparatively easier to manufacture. By proper management both can be brought to bring large returns; and as ice cream is made from the cream and casein from the skim milk, they should naturally be manufactured together in the same plant.

It may be argued that scientific education is not particularly needed in the production of the nonfermented dairy products. This is true to a cer-

tain extent only, for it must be remembered that all milk products, and particularly the raw product itself, are subject to fermentation or contamination. Knowledge of fermentation-bacteriology is therefore of great advantage in this particular branch of dairy industry, and the fermentologist is the better fit to undertake it.

It is unnecessary here to describe the nature of ice cream, and its process of manufacture. It is perhaps one of the most profitable milk products, and one which can be made with comparatively little machinery expense. In 1910 a gallon of ice cream cost the producer approximately 45 cents; the average wholesale price was then 87 cents a gallon, leaving a margin of 42 cents a gallon. During the last few years the prices of raw material have increased, but the wholesale price has increased in proportion. For further details concerning the cost of machinery and manufacture, as well as profits obtained, see the article by S. C. Thompson in the 27th annual report of the Department of Agriculture, Bureau of Animal Industry, 1910.

For methods of manufacturing ice cream, formulas, flavors, etc., see the bibliography. For new flavors, consult the Synfleur Scientific Laboratories, Monticello, N. Y.

In the Iowa Experiment Sta. Bull. No. 140, methods are described for making a new kind of ice cream, from buttermilk (see bibliography).

In manufacturing ice cream and casein from whole milk, large quantities of whey are obtained

as a by-product, and the value of this should not be disregarded. It is usually spoken of as a product not worth while bothering with, because it does not contain much of anything (for its composition see under Whey); and consequently it is disposed of in the quickest and easiest manner. It is my firm belief, however, that if due attention were paid to this "by-product," it could be utilized with advantage as a basis for food products, either as such, or properly treated. (See suggestions under Whey.)

Fermented Milk—(Buttermilk).

The term "Buttermilk" is used in speaking of all fermented milks for consumption. It is applied properly only when referring to the fermented milk which remains after churning the sour cream in manufacturing butter.

The various so-called buttermilks on the market are prepared by fermenting the surplus skim milk, and there is a fair demand for a good buttermilk of agreeable aroma and flavor.

The history of fermented milks used as a food reaches back to the oldest times, but we must here limit ourselves to references on this subject (see bibliography).

The best known buttermilks, characteristic of the countries where they are consumed are Kefir, Koumiss, Yoghourt, Leben, Matzoon, and others. These are all products of a combined lactic acid and alcohol fermentation of milk from different domestic animals. The chemical composition and microscopical aspect are different for each of them, and

two samples of the same buttermilk may even vary, for they are all products of spontaneous fermentation.

The main portion of organisms in these fermented milks consists of lactic acid bacteria of various kinds, some of which produce lactic acid alone, others lactic acid (from 0.5 to 4%), acetic acid, traces of other organic acids and alcohol. They all contain lactose-fermenting yeasts, producing alcohol (from 0.5 to 3% or more) and carbonic acid. Torulae are of frequent occurrence also in these fermented milks, while they are as a rule contaminated with a number of other organisms.

A detailed description of the above mentioned fermented milks may be found in the literature (see bibliography). Bacteriologic examinations of them have revealed that they generally owe their acidity mainly to a certain bacillus, or group of bacilli, to which has been given various names: Dispora caucasica (Kern), Bacillus caucasicus (Freudenreich), Bacillus bulgaricus (Metchnikoff, Gregoroff), etc. Whether or not these bacilli are identical has never been definitely agreed upon, although some authors claim that the Bac. bulgaricus A (Metchnikoff) as found in Bulgarian buttermilk, is different from the rest belonging to this group. The common characteristic of this group of lactic acid bacteria are: that their optimum is high, 40-45° C (104-108° F.), at which temperature they rapidly ferment the lactose in milk, under production of a high percentage of lactic acid (up to 3.5-4%), traces of acetic and other organic acids, and traces of

alcohol. The ordinary lactic acid bacteria have a much lower optimum, and seldom produce more than 1% of lactic acid in milk. Furthermore the lactic acid produced by the Bac. bulgaric group is of the inactive variety, while that produced by the ordinary lactic acid bacteria is laevorotatory.

Concerning the morphology of this organism, consult the literature.

Metchnikoff isolated the Bac. bulgaricus A from Bulgarian buttermilk, and his studies of this organism gave birth to the "Metchnikoff theory," which briefly is this: When buttermilk of this type is taken as a daily food, with a diet consisting mainly of carbohydrates, the Bacillus bulgaricus survives the acidity of the stomach, and passes into the intestinal tract. By their ability to develop and produce lactic acid in the intestines, they combat and destroy those bacteria which, due to their toxic products, are harmful to the system. These latter belong mainly to the colon group and are not able to grow in a too highly acid medium. To this theory is ascribed the longevity of the races whose main food consists in fermented milk of this type.*

Buttermilk containing the Bac. bulgaricus has for this reason a higher reputation than ordinary buttermilk, especially among physicians. With regard to its general food value, however, it is not superior to any other buttermilk. All fermented milks contain very little fat; but on the other hand, they have the advantage over whole milk in that

*Elie Metchnikoff, "The Prolongation of Life."

the casein, due to the fermentation, is present in a finely divided form, making the product easier to digest.

A good buttermilk should answer the following requirements:

1. It should have a thick, uniform, creamy consistency.

2. It should keep this uniform consistency for at least several days if kept in the refrigerator.

3. It should have an agreeable, slightly sour taste, and clean, sour, butterlike smell.

The buttermilks in this country are substitutes for the fermented milks mentioned above. They are put on the market under various fancy names, and vary greatly in consistency and taste, mainly due to the fact that most of them are not made from pure cultures.

Buttermilk should be made from pasteurized skimmed milk, using pure cultures to produce the fermentation. Some of the dairies in the larger cities are now preparing their buttermilk in this way. No other method will yield a uniform product, and it is the good and uniform quality of buttermilk that determines the sales price, which at the present time varies from 6 to 15 cents a quart. A vigorous culture of one single species of lactic acid bacteria, either isolated from a spontaneously fermented milk of good quality, or purchased on the market, will yield a satisfactory result.

Or a combination of a lactic acid bacteria and a lactose-fermenting yeast may be used. The yeast culture, when added in proper amount, gives the

final product a more uniform and creamy consistency, and a refreshing taste, due to the small amount of alcohol (from 0.5 to 2 per cent) and carbonic acid.

Or the milk may be divided into two equal parts; one fermented with the lactic acid bacteria, alone or combined with the yeast, the other with Bac. bulgaricus, to the acidity of about 1 per cent. The two are then thoroughly mixed. This method yields a product similar to Yoghourt.

Various pure cultures for this purpose may be obtained on the market. A good butter-starter may also be used. The temperature by which the fermentation is conducted depends upon the particular organism used. When the desired acidity or taste is obtained, the product is cooled, vigorously stirred, and bottled.

The ordinary lactic acid bacteria usually require a temperature of from 85 to 95° F. to ferment the milk within 8 to 10 hours. When using the Bac. bulgaricus, which is also obtainable on the market, conduct the fermentation at 100 to 110° F. until the product has an acidity of about 1 per cent, then cool as quickly as possible to prevent the milk from becoming too sour.

Bac. bulgaricus often produces a somewhat slimy buttermilk; however, not to any undesirable extent. The slime formation soon ceases by repeated transference of the culture or by vigorous shaking of the product.

Machinery for the manufacture of large quanti-

ties of buttermilk may be purchased from dairy outfit companies.

Cheese

The cheese industry in the United States is rapidly advancing. A number of mycologists, chemists, bacteriologists and cheese experts have been employed during the last years by the Department of Agriculture of the United States Government, with the result that cheese-making has been put on a more solid basis, scientifically as well as commercially. Special attention has been paid to the manufacture of the popular Cheddar cheese, Swiss cheese (Emmenthaler), Roquefort, and Camembert.

This common, everyday food—cheese—is a beautiful example of a fermentation product. The milk is fermented by lactic acid bacteria, the curd separated, and this curd, consisting mainly of insoluble casein, is subjected to fermentation by a number of different organisms, whereby it becomes partly soluble and is changed into an easily digested food. This latter process of fermentation is also called "ripening."

The many factors involved in this process of "ripening" cheese are of a complex character and are as yet far from being fully understood. Each individual type of cheese, with its particular aspect, taste, smell, etc., is a problem by itself.

Certain facts with regard to the character of the processes of manufacture have, however, been fairly well established. The milk curd consists of paracasein, and this is a product either of the lactic acid fermentation alone (such as in cottage cheese,

pot cheese, bakers' cheese, etc. See later), or it is a product of the combined action of rennet and lactic acid bacteria. Rennet is an enzyme, or mixture of enzymes, secreted in the stomach of various animals. It is usually prepared from calves' stomachs, and may be obtained on the market either in powder or liquid form. The process of making cheese of the hard variety, such as Cheddar cheese and Swiss cheese, is roughly as follows: The rennet is added to curdle the milk, and this is facilitated by the addition of a lactic acid bacteria culture. Casein is thereby changed into paracasein. The firm curd is cut so as to separate the whey from it. To complete the separation, the curd is often run through a special mill, whereafter it is wrapped in cheese cloth and pressed. After taking it out of the press, it is left to ripen, that is, to ferment. The lactic acid produced by the rapidly developing lactic acid bacteria combines with the paracasein, forming paracasein monolactate. At the same time these lactic acid bacteria activate the pepsin contained in the rennet, enabling it to decompose the insoluble paracasein into soluble products (albumoses, peptones and higher amides). During the first period of ripening, certain peptonizing bacteria attack the paracasein, and the enzymes, which they produce, also decompose the paracasein into soluble and easily digested products. Simultaneously, other bacteria attack the fat, forming aromatic compounds, which produce the characteristic cheese taste and smell. The peptonizing bacteria soon succumb, while the lactic

acid bacteria continue to increase in numbers for some time; these latter, however, are also checked in their growth, so that the final ripened cheese contains only a fraction of the bacteria originally present.

In most cheese of the soft variety (Camembert, Brie, Servette), and also in cheese of the Roquefort type (French Roquefort, Italian Gorgonzola, Hungarian Brinse, English Stilton) certain molds play a very important part in the fermentation. In French Roquefort cheese, for instance, the milk fat is hydrolyzed by Penicillium Roquefort, a mold which produces water-soluble lipase. This enzyme is the chief factor in the hydrolysis of the fat, whereby the fatty acids accumulate in both free and combined forms. Some of these acids and their hydrolyzable salts have a peppery taste and a burning effect on the tongue, and they give the cheese its characteristic aroma and flavor.

The micro-organisms, therefore, play the greatest part in cheese making. It is not possible to make a cheese of a definite, particular character without the presence of certain definite species of micro-organisms. The lactic acid bacteria are indispensable in the process of fermentation in all of them.

The following organisms have been isolated and found to be active in the production of the various types of cheese, in the manner described above:

American Cheddar: Bact. lactis acidi, and peptonizing bacteria, presumably Micrococc. casei liquefaciens.

Swiss (Emmenthaler): Bact. lactis acidi, Bac.

casei, belonging to the Bac. bulgaricus group; and Micrococc. casei liquefaciens.

Edam: Streptococcus hollandicus (a slime-forming lactic acid bacteria), and peptonizing bacteria.

Limburger: Bact. lactis acidi, Paraplectrum foetidum, and others.

Roquefort: Bact. lactis acidi, peptonizing bacteria, Penicillium Roqueforti (P. glaucum?), and Oidium lactis.

Camembert: Bact. lactis acidi, peptonizing bacteria, and Penicillium Camemberti (P. candidum Rodger).

In French Brie and other soft varieties of cheese, Oidium lactis plays the principal part. In Norwegian Gamelost (old cheese) different species of Mucor, Penicillium, and Dematium are responsible.

But the exact bacteriology of cheese is not known. Great uncertainty and confusion exist in our knowledge of the character and classification of the cheese organisms; and the understanding of it is made more difficult by the variation in the terms used by different investigators for organisms that have been, or may be, found to be identical. Duclaux groups all the peptonizing bacteria under the common name of tyrothrix, that is, bacteria which secrete a trypsin-like enzyme, and are supposed to belong to the Bac. subtilis group. Bact. lactis acidi is a common term for a great many varieties capable of fermenting lactose into lactic acid; Streptococcus lacticus and Bact. lactis acidi Leichmann are probably identical. Some authors

claim that Bacillus casei and Bac. bulgaricus are identical, while others deny this.

The successful manufacture of cheese is controlled by many important factors, such as the quantity and quality of rennet and the starter (culture of lactic acid bacteria), the temperature of curing, the degree of acidity when cutting and separating the curd, and the salting of the same, the temperature and ventilation in the rooms for fermentation, storing, etc. For detailed description of the technical procedures and the machinery necessary, consult the literature (see bibliography).

In view of the difficulties experienced in making uniform products, for the reasons just stated, many more or less successful attempts have been made to use pasteurized milk and pure cultures in the manufacture of cheese. The objections to pasteurized milk have been, that the galactase, an enzyme present in milk and supposed to play a part in cheese fermentation, is destroyed; and that the pasteurized milk curdles slowly, producing a curd difficult to handle. These objections have now been overcome so far as the American Cheddar cheese is concerned, by adding small amounts of hydrochloric acid simultaneously with the rennet and culture.*

The characteristic flavor and aroma in Roquefort, Camembert, Brie, and others, have been successfully produced by pure cultures of the respective molds. Pure cultures of Bac. bulgaricus have

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* "The Manufacture of Cheese of the Cheddar Type from Pasteurized Milk."—J. L. Sammis and A. T. Bruhn: U. S. Dept. of Agric., B. A. I., Bull. No. 165, 1913.

been used with beneficial results in the manufacture of Swiss cheese.*

The use of pure cultures is undoubtedly the road to successful results, but it requires extensive study and experimentation, such as has been splendidly begun by a number of scientific men all over the world. And it would be of great benefit if scientifically and technically educated fermentologists, including the brewers, would enter this field and help work the problems out.

In this country the cheese industry would appear to be a profitable investment, because comparatively few varieties are manufactured, and these not always successfully, while large quantities of different cheeses are imported annually, under normal circumstances, from Europe and elsewhere.

Condensed and Desiccated Milk

The manufacture of these products requires extensive machinery. We shall, however, shortly describe them because they are being used more and more by confectioners, bakers, ice cream makers and allied industries, where a convenient, concentrated and stable form of milk is desirable. It is also extensively used by the general public and for export. The total annual consumption in the United States is approximately 500,000,000 pounds.

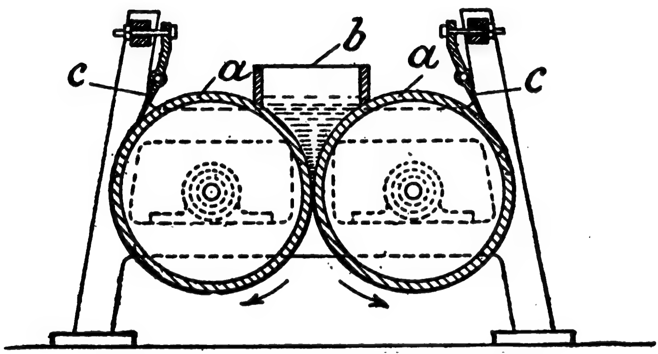
Condensed milk is whole or skimmed milk, evaporated to from one-half to one-fifth of its

* "The Use of Bac. Bulgaricus in Starters for Making Swiss or Emmenthal Cheese."—C. E. Coane and E. E. Eldridge: U. S. Dept. of Agric., B. A. I., Bull. No. 148, 1915.

original volume, under addition of cane sugar as a preservative. The finished product contains approximately 33 per cent of cane sugar.

Evaporated milk is whole milk, concentrated to one-half of its original volume, canned and sterilized, without addition of preservatives.

Desiccated milk is whole or skimmed milk, reduced to powder form (whole milk to about 1/8,



Twin Cylinder Drying Machine for Milk Powders.*

skimmed milk to about 1/11 of its original weight).

The methods of concentrating milk to these forms have passed the experimental stage. It can now be accomplished practically without decomposition, and change in flavor. The addition of water in the right proportion to these products gives a milk of the same appearance, physical properties and nutrient value.

The condensation is effected in special vacuum pans, or by means of hot air passing through the

*Taken from Martin.

milk. The vacuum system is most frequently used and gives the best results.

The desiccation is done by means of special machinery (see bibliography). In manufacturing desiccated skim milk, the yield from 100 pounds of whole milk is approximately 3½ pounds of butter and 9 pounds of skim milk powder.

Desiccated whole milk has a tendency to become rancid, while skim milk powder keeps indefinitely when preserved in a dry state. Both are used as such, or as ingredients in infant and invalid foods, since it is well known that some infants and adults who do not tolerate fresh milk will thrive well on condensed or dessicated milk.

Nestle's and Kufeke's food (Kindermehl) and similar articles are mixtures of desiccated milk with easily digested carbohydrates. Because of the addition of these latter, such foods are proportionately too poor in proteid matter. This is especially true when the food is to be used by convalescent adults. There would certainly be a market for a food of this nature to which more proteid matter (preferably vegetable proteid) has been added in balanced proportions.

Malted milk, manufactured according to patented methods, is presumably desiccated milk, to which malt flour has been added. Those interested in this particular product should procure copies of the patents.

For information concerning methods, technic and machinery for the manufacture of condensed and desiccated milk, see Levi Wells, Yearbook of the Department of Agriculture, 1912, page 335.

Casein

In dairies and creameries where there is considerable surplus of skimmed milk or buttermilk, a profitable business can be conducted by manufacturing casein for technical uses. Average skimmed milk yields approximately 3 per cent, or slightly over. There is an increasing demand for this product, and the price paid for a good one is steadily increasing. It is used more and more in glues and cold water paints, in paper mills for sizing paper, etc., and as a substitute for celluloid, horn, ivory, and similar articles.

It may be manufactured from buttermilk by drawing off the whey, allowing the curd to drain thoroughly and pressing it in layers. These are ground as finely as possible and then dried and powdered.* This method yields a casein which is said to be inferior to that made from skimmed milk, as follows:

Skimmed milk is heated to about 120° F. in wooden vats by conducting steam directly through the milk. Sufficient commercial sulphuric acid is added to coagulate the warm milk; the curd is allowed to settle, and the whey drawn off. The curd is then washed, drained, packed in heavy cloth, and pressed. The pressed cakes are broken up, ground into grains of the size of wheat, spread out in thin layers on wire cloth trays, dried with hot air, and powdered. The powder is put into sacks holding from 100 to 125 pounds each.

For details regarding the manufacturing proc-

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* See also R. Ellersen, The Journal of Industrial and Engineering Chemistry, July 1915, Page 646.

esses and the machinery required see Robert Scherer, "Casein, its Preparation and Technical Utilization."

If the whey separated from the casein is intended for the manufacture of food products (see under whey), another acid should be used instead of commercial sulphuric. The skimmed milk may be subjected to lactic acid fermentation by the addition of a butter starter and left to sour previous to heating and separating. Acetic and hydrochloric acid (free from arsenic) may also be used for precipitation. In St. Etienne, France, large quantities of casein are manufactured by electrolysis of skim milk.

The casein represents the bulk of proteid matter in milk. Several attempts have been made to treat the precipitated casein in different ways so as to purify it and make it fit for digestion in infants and invalids (see Fleischmann "Milchwirtschaft" p. 414). Pure casein should be free from fat, sugar, mineral salts and lactalbumen. It is usually purified by redissolving it in a solution of sodium bicarbonate, from which solution it is again precipitated by the addition of a mineral acid, filtered off, washed, pressed and dried. A casein predigested with pepsin or trypsin has been manufactured in Germany. Others have prepared peptones therefrom by bacteria fermentation. Several soluble caseinates have been offered for sale as invalid foods, the best known being the Sanatogen, said to be a glycerophosphate of calcium caseinate. This latter product and imitations thereof are sold in the United States,

but the medical profession has not found it of greater value than ordinary cottage cheese. Here again it seems worth while to endeavor to find a method of changing the dry pure casein into a digestible form and mixing this with balanced proportions of easily assimilated carbohydrates, affording a substitute for milk and a food for infants and invalids.

Skim Milk and Buttermilk

The buttermilk spoken of here is the sour milk left after churning the butter. These two products used to be and are still in many creameries looked upon as troublesome by-products. They only accumulate and become a source of contamination to the other creamery products if not disposed of quickly, so they are either sold at a very low price, or given away for hog feed, or, still easier, run into the sewer. Such waste is, of course, nonpermissible in a well-conducted business.

In the preceding, products have been described which can be made from both buttermilk and skim milk, viz., cheese, casein, fermented milk, condensed, evaporated and desiccated milk.

Several creameries dispose of all their buttermilk and skim milk by manufacturing cheese of various descriptions, such as cottage cheese, pot cheese, bakers' cheese, etc. The method of manufacturing these may be found in the literature. (See bibliography.)

Some of these cheeses consist of the sour curd alone, separated from the whey by carefully heat-

ing the buttermilk in a tinned or enameled kettle, under constant stirring, to about 120° F., or until the soft curd separates and flows to the top. The curd is then drained and pressed, and mixed with three to five per cent salt and some carraway seeds or other spices, and formed into cakes, which are dried on a wooden board, at an open window.

A delicious cheese may be made from buttermilk as follows: Use buttermilk alone, or mixed with skim milk. If the mixture is not sour enough let it ferment until it has the acidity of buttermilk. Heat as mentioned above, separate, drain, press, and salt the soft curd. Take it out of the press, and leave it a couple of days in a dry, fairly warm place (85-90° F.). Now cut and granulate the curd, and fill clean wooden boxes or containers, to the depth of 2 to 3 inches, cover and set aside for fermentation in a warm place, isolated from all other dairy products. The fermentation is continued until the curd is changed into a yellowish tough dough. This is put in a dish and mixed with a little milk or thin cream under constant kneading and slow heating, until it is so warm that it can hardly be worked with the hands. It is then salted and packed into cone-shaped tin forms, coated with butter or oil. These are placed wide side down on a board, where they remain until the cheese is cold. The forms are then lifted off and the cheese stored in a dry place for a few days, whereafter they are ready for the market.

In making cheese from buttermilk it is essential to prevent molding during the process.

Whey

Whey is obtained as a by-product in creameries, cheese and casein factories. It is a yellowish or greenish fluid, containing lactose, lactic acid, mineral salts and albumen, with traces of casein and fat in suspension. The percentage of these ingredients vary naturally according to the treatment to which the milk has been subjected.

As the whey is a favorable medium for bacteria, molds and yeasts, it rapidly becomes contaminated, and the factories must therefore dispose of it as quickly as possible. This unfortunately is often done in a wasteful manner, either by selling it at a nominal price or throwing it away. It is regarded as a product that has very little commercial value, as such, and which can not be made to yield a greater return. While the first is true, the second deserves further consideration.

Too little attention has been paid to the utilization of this product. Truly it is used in large quantities for manufacturing milksugar, but this is not a profitable undertaking for the average dairy concern, as it requires special machinery and facilities. But the dairies should endeavor to utilize their whey by turning it into food products, either solid or liquid, which could find their way to the table and the soda fountain.

The whey from whole milk contains a larger amount of fat than that left from buttermilk, skim milk cheese, or casein. It has approximately the following composition:

	Per cent
Water	92.7
Fat	0.75
Albumen	1.00
Lactose and lactic acid	4.90
Mineral salts	0.65

The fat may, however, vary from 0.4 to 0.9%. As long as it is not below 0.4% the whey may be used for the manufacture of whey-butter, providing that the quantity at hand is large enough to make this a profitable business. It is estimated that the cheese factory that handles a quantity of whey not less than 10,000 pounds a day can obtain good profits from the manufacture of whey-butter.

Whey-Butter:—Where a centrifuge is available, the whey may be run through it, whereby the remaining cream separates. This cream is then churned, and salted in the usual manner.

Or the whey may be heated to about 160° F., with the addition of 1% of sour whey or butter starter, then heated further to 180-200° F., whereby a thick skum forms on the surface, to an extent of about 3% of the total volume. This is separated, churned and salted.

It is also practiced now and then to leave the whey in a cool room, or in cold water for 24 hours. The cream mounts to the surface and is separated, churned and salted.

Whey Cheese:—A more attractive name for this product would perhaps be desirable. It is manufactured in large quantities in the Scandinavian countries under the name of "Myseost" (whey cheese).

This so-called cheese consists of:

	Per cent
Caramelized milk sugar	46 -61
Fat	0.1 -10
Lactic acid	0.02- 0.42
Albumen	6.5 - 9
Water	24 -38

It may be made from all fresh whey, with the exception of that obtained from manufacturing casein by addition of sulphuric acid. The richer the whey is in fat, the better the final product. The original Norwegian product is made from whey of goat's milk, but whey from cow's milk can very well be used.

The whey is evaporated on an open fire or by steam, in large flat pans. When it has almost reached the boiling point a thick skum forms on top (albumen and fat). This is taken off and reserved for later. The heat is then increased, and the whey evaporated under constant stirring to about one-third of its original volume. The above mentioned mass of albumen and fat is now added under stirring, and as soon as the mixture has become so thick that it will "stand up" it is taken off the fire. But the stirring is continued until the mass is so stiff that stirring becomes impossible. It is then transferred to a wooden trough, and cooled under constant kneading with a wooden pestil, to prevent the sugar from crystalizing. When cooled to about 80-90° F. the mass is pressed into square wooden forms, which can be opened up from the sides, and the surface is smoothed with a knife. It is left in the forms until the next day, then taken out and

put on a wooden board, and stored for a few days, after which it is ready for the market. It is a peanut butter colored "cheese" of agreeable taste, and high nutrient value. We believe the American public would relish it.

One hundred pounds of whole milk, when handled right, would yield 3 to 3.5 pounds of butter, 4 to 5 pounds of cheese from the skim milk, and 6 to 7 pounds of whey cheese.

Vinegar:—The whey is evaporated on a steam bath until it contains from 11 to 12% of lactose. While boiling it is neutralized with calcium carbonate or sodium carbonate, filtered, cooled to about 70 to 75° F., and inoculated with a pure culture of a lactose fermenting yeast. After fermentation, the liquid contains 5 to 6% alcohol. It is then filtered, and a pure culture of acetic acid bacteria is added, after which the mixture is left to ferment. The final product contains from 5 to 6% of acetic acid.

Another kind of vinegar may be made from whey by bringing it up to the boiling point, under the addition of about 1% of glucose (commercial), cooling the mixture to 100-110° F. and adding a pure culture of Bac. bulgaricus A. The temperature during the fermentation should be kept at 100 to 110° F. Bac. bulgaric. produces from 3.5 to 4% of lactic acid. When this temperature is reached the bacilli quickly succumb, and settle to the bottom. The liquid is then syphoned off or filtered, and sold as such or concentrated to the desired acidity. This may prove to be a vinegar of similar character to

that made from beer wort by fermentation with Bac. Delbruecki, which latter organism does not ferment lactose.

We might finally venture to suggest that it be tried to make a fermented drink of whey. E. Kayser* has produced a refreshing beverage by adding 3% of cane sugar to the whey, heating to boiling, cooling, and adding a pure culture of a lactose fermenting yeast. The fermentation was conducted at a low temperature and the product tasted somewhat like cider.

It would also seem probable that a good ginger ale could be produced by adding a ginger extract to the above mentioned sugared whey before fermenting it.

Whey is also used in Europe for the manufacture of a table syrup, called "whey honey." It is prepared by adding sugar to the whey, in the proportion of one pound to one quart, and boiling the mixture down to the proper consistency.**

For whatever purpose the whey is used, it should be handled with the utmost cleanliness. Pasteurization will preserve it for some time.

It is hoped that this chapter on "The Dairy Industry" may be of some assistance to the student, stimulating his interest in this industry and his desire to study the subject further. The few references offered in the bibliography should help him to this.

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*Contribution a l'etude physiologique des levures alcooliques du lactose.

** Sugar and its value as food, U. S. Dept. of Agriculture, Farmers' Bulletin 535, 1913.

The study of fermentology, chemistry and technology, as related to the dairy industry, is fascinating because it not only informs the student of the brilliant ideas conceived by scientists and applied to this industry, but also opens his eyes to the many opportunities for new ideas, new methods and new products.

X. Industrial Alcohol.

Manufacture of Ethyl-Alcohol.

By Dr. Leo Stein.

THE production of Ethyl-Alcohol, its extraction from fermented liquids was known to the Arabians in the 8th century. The Alchemists found it in their search for the rock of the sages, although only in diluted form. Raimundus Lullus showed in the 13th century that alcohol could be produced in concentrated form by dehydration with potash. The monks in the middle ages distilled it and used it for medicinal purposes. Not until 1796 was absolute alcohol produced.

Alcohol as such is found in nature. It is contained in certain fruits, namely: Pastinacia Sativa, Heracleum giganeum. The atmosphere contains traces of alcohol. Muentz found one gramm of alcohol in one cbm. of rain water. Alcohol is present in humus, in fresh bread, and is found wherever sugar comes in contact with the ever-present yeast cells, which produce alcohol and carbonic acid. Therefore all fermented beverages contain it, and it can be obtained therefrom through distillation.

Alcohol is manufactured for drinking or for technical purposes, which determines the raw materials to be employed.

For drinking purposes wine, cider, barley, rye, corn, potatoes, rice, etc., are used; for technical purposes sugar beets, molasses, and of late, saw-dust. (Cellulose.)

All technical alcohol can be used for drinking purposes, when purified.

Alcohols for drinking purposes are distinguished by their aroma. Cognac is produced from wine, rum from molasses, arrak from rice, whiskey is made with the aid of malt, and there is a pure malt whiskey and others, which are made from malt and unmalted cereals. Scotch Whiskey is characterized by a peculiar aroma, which is caused by the kiln-drying of the malt with peat (peat flavor). Alcohol when leaving the still is colorless. The color of cognac, apple-jack, whiskey, is either due to extracted matter from the storage barrels or to the addition of caramel, burnt sugar.

The production of alcohol is simple, whenever sugar is the raw material. When starch is used, this must be converted into sugar. For this purpose diastase is necessary. With the manufacture of alcohol the production of malt is, therefore, often associated. Alcohol from starch is produced without the use of malt, according to the amylo process, with Taka-diastase, by conversion of starches with acids, by conversion of saw-dust with acids, fermenting the resulting sugar and final distillation.

The malt used in the distillery is preferably green malt. It would be non-economical to use kiln-dried malt, as this has lost part of its diastatic power; many, however, use kiln-dried malt. As in the brewery, barley malt is used in the distillery, rye only for rye whiskey. Preference is given to barley, which is rich in albumen, poor in starch, having a

low bushel weight, and showing at least 95% germinating capacity.

The malting is done in the usual manner, either on the floor or in drums. Frequently lime water is used for steeping, as a better germination is obtained, especially with young barley. The object is to obtain the highest possible amount of diastase; in Germany so-called long malt (lang-malz) is made. While malt for brewing is kiln-dried after five or six days, the distiller permits the malt to grow for about 14 days. Naturally the losses through germination are high, but the diastatic power of long malt, compared with short malt, according to Hayduck, is almost double. The temperature during sprouting shall not exceed 15° C.

To save labor, so-called felt malt (Filzmalz) is also made. The barley sprouts in boxes, is not turned, acrospire and rootlets become entangled, forming a felt-like mass. The length of the acrospire in the case of long malt is two to three times that of the grain. Before using green malt it is crushed in special machines, and in order to destroy bacteria, it is treated with antiseptics.

The mashing process is similar to that used in the brewery, the distiller making first beer, as he calls it. The principal difference being the small amount of malt used (excepting the pure malt whiskey), and above all the mashing temperatures employed.

For gelatinizing the starch of the adjuncts, cookers are used. When making alcohol for beverages open and closed cookers are used; for technical

alcohol the closed cooker is preferred, as the yield is greater. It is assumed that the closed cooker disadvantageously influences the taste. Just as the brewer the distiller adds some malt to the cooker mash to better liquify it. Usually the cooker is also used as a mash tub. Nevertheless we find in the distillery just as many various methods of operation as in the brewery. For saccharification the cooker mash is cooled, and at 56° to 60° C. (45° to 48° R.) the malt is gradually added while stirring.

The distiller employs exactly those temperatures which the brewer evades. While the brewer wants to produce unfermentable dextrines, the distiller's object is to produce fermentable substances only. The worts employed for fermentation weight 18—22° Balling.

The amount of malt used varies. In Germany where potatoes are used principally, 4.5 to 6 parts of long malt, representing 3 to 4 parts barley are used to 100 parts of potatoes. Corn mashes are produced with 10 to 15% of malt.

It is customary to add disinfectants to the mash in order to prevent the growth of bacteria. The distiller fears the bacteria as much as the brewer. Bacteria causes false, often stormy fermentation, produces off-taste, and decreases the yield in alcohol, for bacteria consume sugar the same as yeast does. For the disinfection of the wort, such quantities of fluoric acid or formaline are used that the yeast may not suffer.

After ending the mashing process the mash is cooled and fermented with yeast. Formerly a sur-

face cooler was used, today the counter current cooler has generally superseded it. The mash is cooled to 30° C. (24° R.) at which temperature the mash, containing all the grains, is pitched with yeast.

The yeast employed is cultured yeast (Kunsthefe). Only special high fermenting types are used which are obtained from a scientific station at the beginning of the distilling campaign. The yeast must have a great resistance against certain disinfectants and must retain its activity in the presence of large quantities of alcohol. The production of distiller's yeast (Kunsthefe) is a sort of propagating process in a previously acidified medium. Usually the acidification is done with a lactic acid culture, lately also with sulphuric or fluoric acid. The presence of acid is necessary, as acids support the fermentation, while bacteria are suppressed. Wherever lactic acid cultures are used, the lactic acid bacteria are destroyed by heat before the yeast is added to the medium.

The sulphuric and fluoric acid process is more and more adopted as time is saved. Lately an addition of rosin is employed; rosin acts as an antiseptic, similar to the hop resins in beer wort.

The distillery is fitted out with small or large fermenting tubs, made of wood, cement, copper, or enameled iron, the same as in the brewery. The closed fermenting tub is more frequently employed of late.

We distinguish the primary, the main, and the after fermentation. During the primary fermenta-

tion the yeast multiplies; after twelve hours the vigorous main fermentation sets in and lasts about twelve hours. Wherever compressed yeast is made the rising yeast foam, which forms after twelve or sixteen hours, is collected, washed, mixed with starch and sold in cakes. In the United States compressed yeast is made with filtered wort in copper fermenting vats. This yeast is free from grains and is generally sold without the admixture of starch.

During the after fermentation, the more difficult fermentable dextrines are worked up and the entire fermenting process is completed after 48 hours, mostly after 60 hours. The revenue authorities of the United States prescribe a maximum of 72 hours for the fermentation. The highest permissible temperature is 29° C. (23° R.). At higher temperature a loss of alcohol takes place, and the growth of bacteria is encouraged. For controlling the temperatures of the fermenting mash, as in the brewery, cooling apparatus is used in the distillery.

The distiller aims for a complete end-fermentation. The Balling indication of a potato mash is at the end of the fermentation 0.2 to 1.5. The saccharometer indication (apparent attenuation) of corn mashes is often below zero. Should the fermentation be retarded through excess formation of alcohol, the mash is diluted with water. Open fermentation tubs must be covered toward the end of the fermentation to prevent the loss of alcohol; the escaping carbon dioxide is aften washed to retain the alcohol in the wash-water.

The introduction of certain fungi used instead of malt, as a saccharifying agent, we owe to the Japanese Takamine. He employs the Aspergillus oryzae, which is used in Japan for the manufacture of the Japanese rice beverage, Saki. This fungus as well as other fungi of the same class produce through their own diastase, which is used for the saccharification of starch. Taka-Diastase can be bought in dry form.

The Amylo-process of Boidin and Calmette is based on the same principle. Living fungi cultures are employed, and because the operation takes place in closed vats, this method is very pure; the yield comes nearest to the theoretical.

In the United States a large amount of alcohol is made from cane sugar molasses. The cheapest grades are used. (Black strap.) Beet sugar molasses is also used, however, the resulting alcohol is characterized by a bad taste and odor. The working method is simple because ready sugar is present. The molasses is boiled, diluted to 20° Balling; sulphuric of phosphoric acid is added and fermented with a special molasses yeast.

The production of ethyl alcohol from saw-dust is yet in its infancy. At present only one concern is operating this process in the United States. The saw-dust is treated under pressure in closed converters with acid, by which sugar is formed from cellulose. Beside the fermentable "Hexoses" many unfermentable "Pentoses" are formed. This method is, therefore, characterized by a poor yield, which

is about 20 gallons of alcohol from one ton of sawdust.

In every case the fermented mash is brought to the distilling apparatus which varies in construction. The more modern are heated with steam, work continuously and are often of gigantic proportions. They are connected with charcoal filters. Some have a capacity of 15,000 bushels of corn per day. The product in one operation is alcohol of 96 per cent strength and of great purity. Simultaneously the valuable fusel-oil is obtained. The residue is slops, which is used as fodder, either in wet or dried form. Potash can be gained from molasses slops.

The distilling industry is under control of the Internal Revenue Department. Distilling apparatus and storage vessels are under lock and key. The tax in the United States is $1.10 per one gallon 100-proof alcohol (50%). Denatured alcohol is tax free.

For denaturing purposes crude wood alcohol and benzine are used in the United states. Manufacturers of spirit varnishes are permitted to use a specially denatured alcohol, which contains only 5 per cent of crude wood alcohol.

The yield of alcohol stands in direct proportion to the equipment and the efficiency of the plant. Depending on the market and the season different raw materials are used in the same distillery.

One (1) bushel of corn (56 lbs.) yields on the average 16.56 lbs., equal to 2.5 gallons absolute alcohol. (The theoretical quantity is 26.66 lbs.)

One bushel of rye (56 lbs.) yields 2.38 gallons of alcohol, on an average.

One gallon of molasses (11.75 lbs.) with 50 per cent fermentable sugar yields on an average 2.81 lbs. of alcohol or 0.425 gallons.

For labor, fuel, depreciation of machinery, etc., 12c to 13c is figured per gallon of alcohol of 190-proof, when made from corn; 10c when made from molasses.

The production of 1 gallon of alcohol of 190-proof costs in normal times, from corn, about 40c; from molasses, about 33c.

The consumption of alcohol in the United States for drinking purposes was 146 million gallons in 1916.

The production of denatured alcohol was about 35 million gallons and is rising rapidly. The manufacture of this alcohol has the greatest possibilities for the future owing to the rapid depletion of our oil fields.

Dr. L. S.

Uses of Alcohol

By far the greater number of its uses may be grouped chiefly under four or five heads, as follows:

A—As a solvent and extractant.

B—As a precipitant.

C—As a sterilizing agent and disinfectant.

D—As a raw material for the preparation of other products.

E—As a fuel.

In the great majority of cases it has so far been

impossible or impracticable to replace it with any other known material.

Alcohol in Foods and Beverages

Traces of alcohol are inevitably present in many foods commonly and widely eaten, especially fruits. Many of the higher plants produce small amounts of alcohol during their normal life processes, so that the production of alcohol cannot be held to be an exclusive feature of the common fermentation of sugar by yeast. Such minute amounts as may be taken in the ordinary food in this manner are apparently entirely oxidized by the body, thus serving, in a minor way, as a source of energy. The body can thus oxidize and use as a fuel not inconsiderable amounts of alcohol, especially when foods of the carbohydrate class (starches and sugars) are withheld.

Alcohol in Medicine

In the ninth decennial revision of the "Pharmacopoeia of the United States," which became the legal standard for the country on September 1, 1916, under the pure food and drug act, alcohol is included in three concentrations—99 per cent, 92.3 per cent and 42 per cent. These three dilutions of alcohol are used in the preparation of extracts and solutions of a great number of the drugs described in this book. The reasons for such use are as follows: First, alcohol is the only known substance which will dissolve a large number of physiologically active substances (drugs), retain them in solution,

suppress the growth of molds and bacteria which would destroy the preparation, and not itself react with the material so as to destroy its activity. Second, it is the only substance known having the above properties, and which is at the same time of such a low degree of toxicity that it may be safely included in a prescription in the amounts in which it is usually present in medicinal preparations.

Alcohol is, moreover, used as the raw material for the preparation of a large number of substances listed in the "Pharmacopoeia." Appended hereto is a list of the preparations listed in the "United States Pharmacopoeia" which contain or are made from alcohol, together with their customary use. It has been observed that in the preparation of the extracts of many drugs the alcoholic extract would be active, while a water extract would be inactive, due undoubtedly, in most cases, either to the active principle being insoluble in water, or being destroyed by water. While some of the pharmacopoeial products are possibly unnecessary, it is frequently essential to have the drug available in both alcoholic and non-alcoholic preparations, for mixing with other drugs of like type, where mixing an alcoholic with a non-alcoholic preparation would result in the decomposition of the mixture.

For instance, it has been found that the preparations of digitalis—the well known and important drug so much depended on in heart diseases of certain types—when made with water are nearly inactive, or lose their activity so soon after preparation as to be worthless, or at best unreliable. Prac-

tically everyone has used, or at least heard of, aspirin; this valuable drug is manufactured by processes employing pure acetic acid—a derivative of alcohol.

Alcohol in the Scientific Laboratory.

Without alcohol the work of all scientific laboratories—chemical, bacteriological, physical, engineering, medical, etc.—would cease. All scientific training in university and college courses would cease or be so seriously handicapped as to be nearly worthless. Alcohol is used as a solvent, as a precipitant, as a purifying agent, as a disinfectant, and as a raw material, every day in thousands of laboratories in this country and all over the world. Much of the alcohol used in laboratory and scientific work must be used in its pure and undenatured state. It is indeed not unusual for the chemist to take the purest commercial alcohol obtainable and so treat and redistill it as to remove the last traces of foreign material before it is considered sufficiently pure for laboratory uses. The denaturing of alcohol, while it has tremendously extended the practicable uses of that important substance, has by no means replaced undenatured alcohol, nor will it ever do so in those classes of work where a pure substance is essential, for the very fact of denaturing is the addition of foreign matter to the alcohol.

At present we know of no substance which can take its place, nor is it likely that any will be discovered, for the groups of organic compounds to which alcohol is related in its properties have been

pretty thoroughly studied, and none is known which will replace this re-agent. As a raw material for the preparation of new organic compounds, alcohol and its immediate derivatives cannot be replaced by any other substance, for any other substance would not result in the same final product. As a solvent for organic materials it is without an equal. As a precipitant in various reactions of the chemical laboratory, no other known substance will replace it. This is not said in praise of alcohol, but simply as a statement that it possesses certain specific properties which make it absolutely essential for scientific work—a combination of properties unknown in any other substance. A list of all the laboratory applications of alcohol would be practically a catalog of all the processes used in the preparation of some quarter of a million organic preparations, not to speak of several hundred inorganic substances.

Value of Alcohol as Fuel

Automobile manufacturers and engineers are predicting alcohol will be the automobile fuel in the future. The only thing that now stands in its way as a universal fuel is the cost due to the raw materials now used, and its limited use as a fuel. The substitution of cheaper raw materials for the manufacture is assured when the demand becomes great enough.

Raw materials which may be used are unlimited, as anything that contains starch, cellulose or sugar can be utilized. This would include waste of the

lumber industry, which includes cellulose and the waste from the sugar industry.

Waste from lumber camps, from the forests and around paper mills which might be used to produce alcohol are now permitted, in many cases, to rot or burn. It has been shown that a ton of dry sawdust will yield from 20 to 25 gallons of alcohol, 95 per cent pure, and from this source alone almost half a billion gallons could be manufactured annually.

The suitability of alcohol as a power producer in internal combustion engines has been proved by a series of tests conducted by the United States Bureau of Mines, and the higher efficiency of alcohol compared to gasoline is due to the following causes:

1. The volume of air required for complete combustion of alcohol is only about one-third that required by gasoline, and thus much less energy goes away in the exhaust. Moreover, this smaller dilution with air enables a more perfect mixture to be formed, with consequent more perfect combustion.

2. The alcohol-air mixture can be safely subjected to pressure of 200 lbs. per square inch without spontaneous ignition, whereas the safety limit for gasoline is 80.

3. All mixtures of alcohol and air containing from 4 to 13.6 per cent of alcohol are explosive, whereas the explosive range for gasoline is from 2 to 5 per cent, necessitating much more careful carburetor adjustment.

4. The combustion products of alcohol are smoke-

less, almost odorless, and do not clog up the cylinders and valves.

The only serious difficulty encountered would be the starting of the engine in cold weather, and this could be provided for by carrying a small auxiliary gasoline tank to be used in starting.

XI. Mechanical Appliances.

IN the course of this work reference has been made to various mechanical processes which find application in some of the industries treated in this book and with which the brewer in many cases is not fully familiar. It may, therefore, not be amiss to devote the last chapter to a somewhat more detailed discussion of these various contrivances.

The subjects to be discussed are:

1. The carbonation and bottling of "soft drinks" in the brewery.

2. The installation and operation of the filter press.

3. Evaporation.

Carbonation and Bottling of Soft Drinks

By R. A. Wittemann.

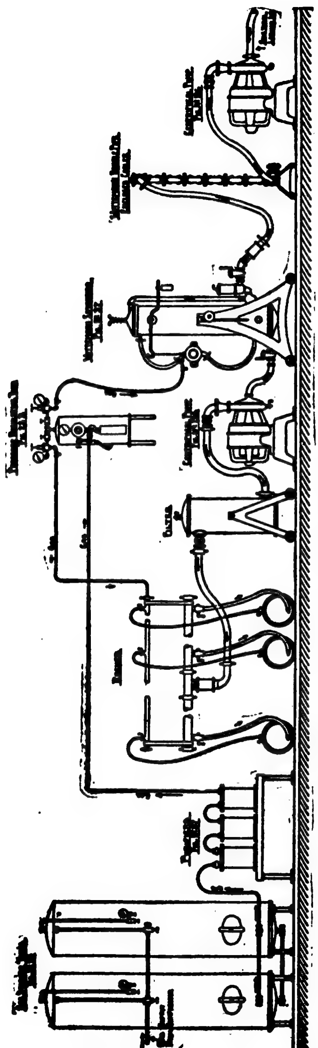
The manufacture of "Soft Drinks" and the so-called non-alcoholic beers and other malt beverages, or ginger ale, lemon soda, root and birch beers, sarsaparilla, etc., is well explained in the foregoing treatise, and it is known that there are innumerable small establishments for this purpose scattered all over the United States. It is also known that some small breweries in outlying districts have attempted to commence the bottling of such soft drinks for many years with more or less advantageous results, but that their distribution of whatever nature has not yielded a large remunerative business, and the out-

put has been comparatively small, mainly on account of the expensive method of manufacture and distribution in costly small packages of glass. Practical experience has demonstrated, even where competition has not been ruinous and where comparatively fair prices were obtained for the finished product, the bottler practically made but a scant living, and students of the subject have determined that the excessive breakage and loss of bottles has been the main contributing cause.

If the distribution and sale could be accomplished advantageously in larger packages, indestructible under ordinary use, and if individual distribution could be made also in glass or in bulk, as for instance beers and ales in drinking places are dispensed, it would certainly prove as remunerative a business as beer has been.

Spasmodic attempts have been made in this direction, but a great stumbling block in the way of the progress of this method has been the costliness of refrigerating apparatus and its maintenance. Fair results have also been obtained in a small way by refrigeration with ice, but the process is costly, both by the necessary purchase of ice, its handling and method of application.

These points remembered, it must be clear to every observer that no place is more adaptable and suitable for the production of non-alcoholic beverages of any kind than a brewery, of which, unfortunately, a vast number have been and will be made idle by political agitation. Even the smallest brewery in the country is provided nowadays with a re-



THE WITTEMANN NON-ALCOHOLIC BEVERAGE CARBONATING SYSTEM.

frigerating plant, and since comparatively little space is required, except for transportation packages, and for tanks to manufacture the product in, no fermentation nor storage being required, it is apparent that the breweries can be employed very readily for the stated purpose, without practically any cost for alteration, except the acquisition of a proper and suitable gas production, carbonating, filtering and filling outfit. These latter are also easily procured. Where fermentation gas is still available, the gas production is at once present, and without cost. Gas is procurable in liquid form in the well-known drums, or it can be profitably manufactured by a suitable generator. In the illustration accompanying this article, such outfits are shown.

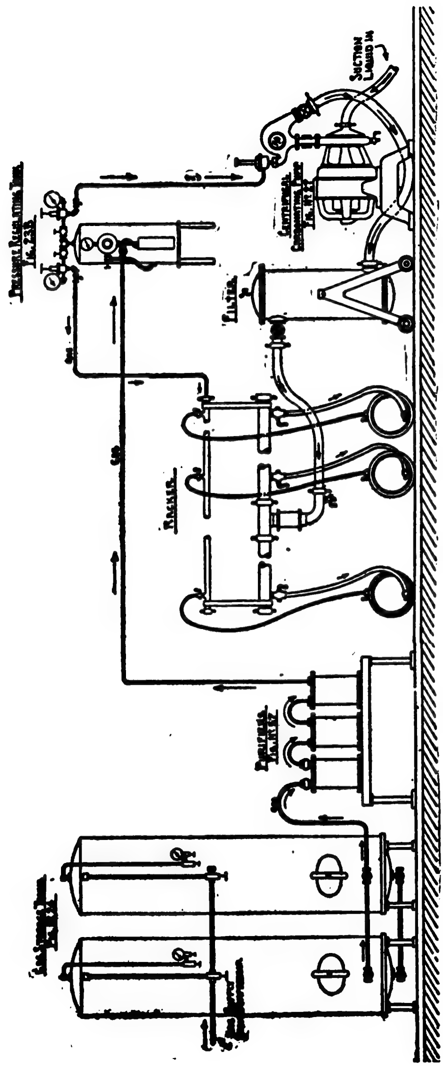
First, one for the production of non-alcoholic beers and malt beverages.

Second, one for charging of soft drinks with available fermentation gas.

Third, one for charging of soft drinks with self-manufactured gas from a generator.

In either case, of course, it is presumed that the product is thoroughly treated and mixed with the selected extract either for body or flavor, and that the refrigeration be at a very low temperature.

Since the United States Revenue Department has granted the privilege of manufacturing of soft drinks in the breweries where regular alcoholic beer also is manufactured, and has given permission to utilize the regular beer shipping cooperage, if the latter is specially marked and distinguished by different colors, it is apparent that no difficulty stands



THE WITTEMANN NON-ALCOHOLIC BEVERAGE CARBONATING SYSTEM

Showing Centrifugal Carbonating Pump

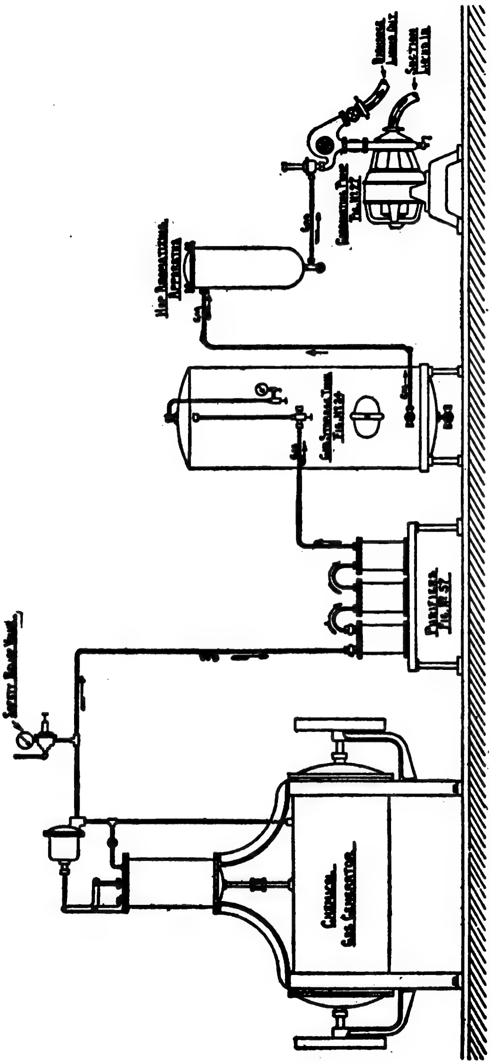
in the way of a brewery to engage in this line. Shipping packages so filled, can be sold to any dispensing place without government or local license, and since a glass of good soda commands anywhere from 5c to 10c a glass, according to its size and flavor, and since the dispensing places, be they saloons, candy stores or drug stores, are fitted up mostly with either ice-boxes or cooling coils under counters, the dispensation of soft drinks at proper temperature and of good appearance is perfectly feasible. Where such dispensation facilities exist, but with air pressure devices, it is necessary to substitute liquid carbonic gas pressure for pumps or other air pressure device, because the soft drinks cannot properly be dispensed with air top pressure.

The Wittemann Company, having thirty years of practical experience in the manufacture and installation of outfits for gaseous beverages of all kinds, stands ready to equip such establishments in connection with the existing brewery apparatus, and a request will bring one of their experts to any location for a thorough and practical exposition of the needful, and estimates of cost.

Installation and Operation of the Filter Press

By D. R. Sperry.

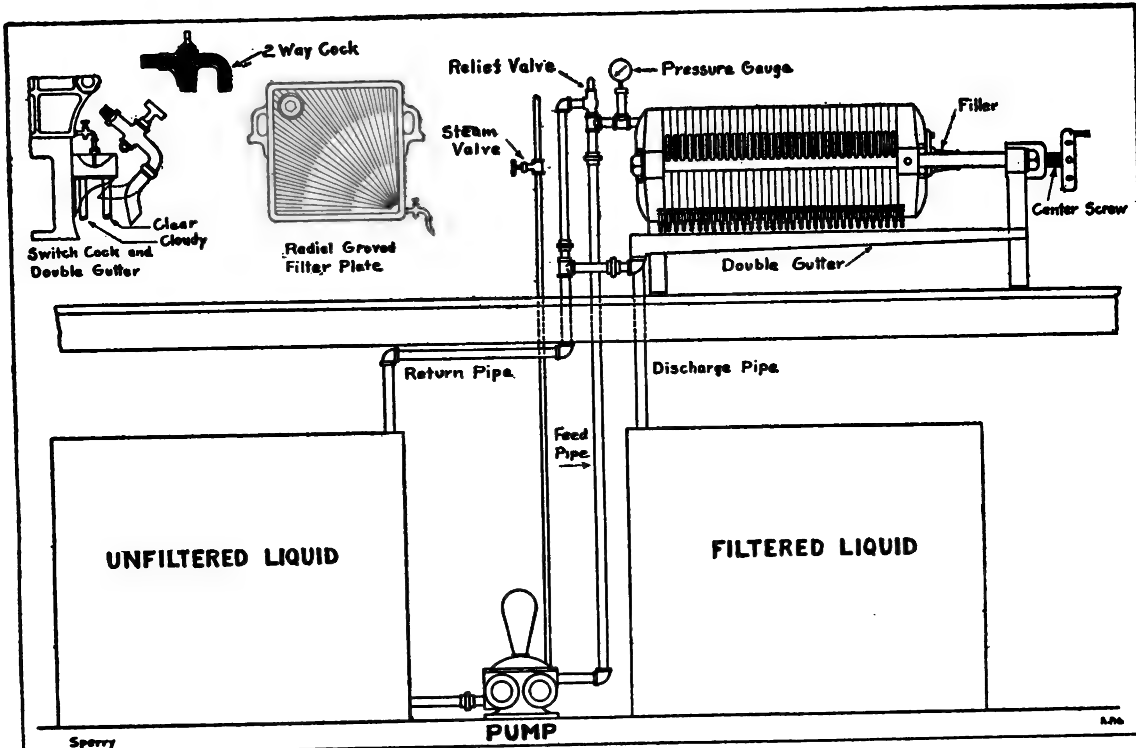
The proper arrangement and connections of the filter press in the brewery depends largely upon existing conditions. Frequently the tank containing the unfiltered material must be located in a certain position because of the room occupied by equipment already in place. Similar-



THE WITTEMANN NON-ALCOHOLIC BEER CARBONATING SYSTEM
SHOWING CENTRIFUGAL CARBONATING PUMP

ly the filter press must often be placed where there is room for it regardless of the location of the supply or discharge tanks. In cases, however, where a new plant is being layed out it is often possible to locate the supply tanks, pump, filter press and discharge tank in the most advantageous locations with respect to each other. Even under these conditions there is, of course, a chance for diversity of opinion. A good arrangement, however, is illustrated in the above sketch. This shows the filter press located on one floor while the supply tank, pump and discharge tank are located on the floor below. By this arrangement gravity is made to aid in carrying the overflow from the relief tank and the cloudy liquor from one side of the double gutter, back to the supply tank. Should a floor pan be placed under the filter press its outlet can be also piped back to the supply tank, gravity aiding in this case also. The clear liquor from the clear side of the gutter flows by gravity into the filtered liquor tank. The pump being placed on the level with the bottom of the supply tank, is always primed and the grease and dirt therefrom is kept away from the filter press.

In operating the filter press the first thing to do is to see that the plates are "Clothed." In clothing a plate a cloth is thrown over it so that both sides are covered. Holes are then made corresponding to the hole in the plate. Through these holes grommets are placed which can be screwed together, thus bringing the cloth to bear against the finished surface surrounding the hole. When all the plates and



Pipe Connections for Filter Press
D.R. Sperry & Co., Batavia, Illinois
May 3 1917 H.R.G.

the heads are thus clothed a certain cycle of events takes place as follows:

(1) Closing.
(2) Arranging cock switches.
(3) Filling and switching cocks.
(4) Opening and cleaning.

"Closing." The plates and heads are all brought together, care being taken to see that the packing surfaces are clean. The suspended filler is dropped into place and the center screw tightened.

"Arranging cock switches." The cocks on all the plates are arranged so that they will discharge into the side of the double gutter which is piped back to the supply tank.

"Filling and switching cocks." The pump is started and the speed is adjusted by the steam valve near the filter press. Undue pulsations are to be avoided and care should be taken to see that the relief valve is properly set. As soon as the various cocks begin to discharge clear liquid they are to be caused to discharge into that side of the gutter which is piped to the filtered liquid tank. Filling is to continue until the cocks nearly cease flowing or until the batch is run through.

"Opening and Cleaning." The pump is shut off and as soon as the pressure gauge shows no pressure the center screw is loosened enough so that the filler can be lifted. When this is done the slide head is pulled back against the center screw leg. The cloth on it and the plate facing it is scraped clean. The next plate is drawn back and its other side scraped, together with that of the plate fac-

ing it. This process is continued until all of the cloths are cleaned. Closing is now in order and the cycle of events repeats itself.

"Filter Plates." In the sketch is shown a filter plate. This is the radical grooved plate, corner feed and is suitable for brewing requirements. The corrugations or grooves upon the plate surface all lead the liquid directly to the outlet. Each side of the plate is recessed one-half inch to five-eight inch so that a chamber between plates is formed one inch to one and one-fourth inches thick. The liquid to be filtered reaches the chambers thus formed by passing through the grommets in the eyes. Since each plate is covered with canvas the material must pass through it to pass out.

"Switch Cock." The sketch also shows a switch cock and its relation to the double gutter. A study of the piping shows that when the effluent from the cock is directed into one side of the gutter the liquid flows back to the unfiltered liquid tank whereas when directed into the other side it flows to the filtered liquid tank. By this arrangement the cloudy first runnings are caused to pass back to the unfiltered liquid tank, to be filtered, thus preventing contamination of the liquid in the discharge tank. Thus for brewery use the double discharge cock and double gutter are very necessary.

Double discharge cocks are supplied in two forms, the switch cock type (as shown attached to the plate) and the two-way type as marked in the drawing. The switch cock is provided with a swivel whereby the issuing stream may be deflected

from one side of the double gutter to the other. The two-way cock has no swivel but by turning the plug in different positions the stream can be caused to flow out of the bottom of the plug into one side of the double gutter or into the other side by causing the stream to flow out of the bibb.

D. R. S.

Vacuum Evaporation

The different forms of apparatus used for vacuum evaporation vary much in their details, but all depend on the principle of reduced pressure. The essential parts of the plant are the vacuum pan or still, the pump for exhausting the air and steam from the pan and sending them to the condenser, and the heating apparatus. The vacuum pan is usually a globular copper or iron vessel, provided with a manhole, a pressure gauge, and a discharging valve. Very often a piece of heavy plate glass is set in the side to afford a view of the interior during evaporation. On the top of the pan is a dome or short tower, from which a pipe leads to a receptacle, called the "catch-all," that retains any liquid which may escape from the pan, and a larger one connects the "catch-all" with the vacuum pump, which is an ordinary double-cylinder air pump of large size, driven by an engine. An injector pump, which condenses the steam directly, may be used. The pan is generally heated by steam coils within it, or by a steam jacket, or by both.

A very efficient method of vacuum evaporation is that obtained by the use of *multiple effect sys-*

tems. In these greater economy of fuel for heating is secured. The apparatus consists usually of two or more simple vacuum pans, so joined together that the steam from the boiling liquid in the first pan is made to pass through the coils and jacket of the second pan, and the steam generated in the second pan goes through the coils and jacket of the third, and so on through the system. The vacuum maintained in each pan of the series is greater than in the one preceding. Hence, notwithstanding its increased concentration, the boiling point of the liquid in the second pan is so low, that the steam from the first pan is sufficiently hot to boil it. Similarly the steam from the second pan is made to boil the liquid in the third, in which there is still less pressure, and so on to the last pan, in which the highest vacuum is maintained. As a rule, only four pans are used, for it is very difficult to sustain the vacuum sufficiently to work another pan in the series. In many plants only three pans (triple effects) are used.

Industrial Evaporation

By F. M. Le Beers, Swenson Evap. Co.

The scope of industrial evaporation work is somewhat larger than is ordinarily recognized. A constantly growing number of chemical and other manufacturing processes require the removal of water from dilute solutions and this evaporation work is an important and indispensable part of such processes.

There are places where an evaporator is used at

an intermediate stage as instanced in glue making, the manufacture of sugar, glucose, etc. In a glue plant the main part of the work is the extraction of the glue from the glue stock and the subsequent handling of the jelly and dried glue.

Where the evaporation product is the main product, the entire plant frequently consists of an evaporator and an apparatus of some form for drying.

Waste products become by-products when properly handled. During the last quarter of a century we have been instrumental in the development of a large variety of by-product industries.

We must be prepared to recognize the widely varying physical and chemical characteristics of solutions to be evaporated. Dilute solutions are presented to us for evaporation having as low as 1½ per cent solids and in other cases of such concentration that the proportion of water to be eliminated is small. In the majority of evaporating plants the hot concentrated solution is quite fluid. However, we have had to handle cases where we finish to a mixture of liquid and solid that quickly solidifies.

Characteristics of other solutions include the tendency to partial or complete precipitation of crystals during evaporation. This may take place while a liquid is being concentrated or in other cases start at a definite saturation point.

Solutions may be composed of amorphous solids of glutenous properties. Another possibility is that certain ingredients in a solution cause a tendency to

foam on boiling. Still other solutions are quite fluid, but of such high boiling point as to necessitate unusual steam temperatures.

We could proceed indefinitely to name special properties of solutions and enumerate distinctive cases, but it is sufficient to say that for successful treatment of the problems arising we must approach them with an active imagination and a dependable knowledge of chemistry, and mechanics. We find that practical experience is of paramount importance, but recognize that a few scientific facts judiciously applied are also necessary.

A combination of practical experience and thoughtful chemical engineering is what we have to offer for co-operation with our customers, engineers or advisors. The facts regarding the properties of the liquids must be recognized and studied by ourselves and those who purchase and operate the apparatus we supply.